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THE MINERAL INDUSTRIES OF PENNSYLVANIA

Trends of the Mineral Producing and Processing Industries

by

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GREATER PENNSYLVANIA COUNCIL

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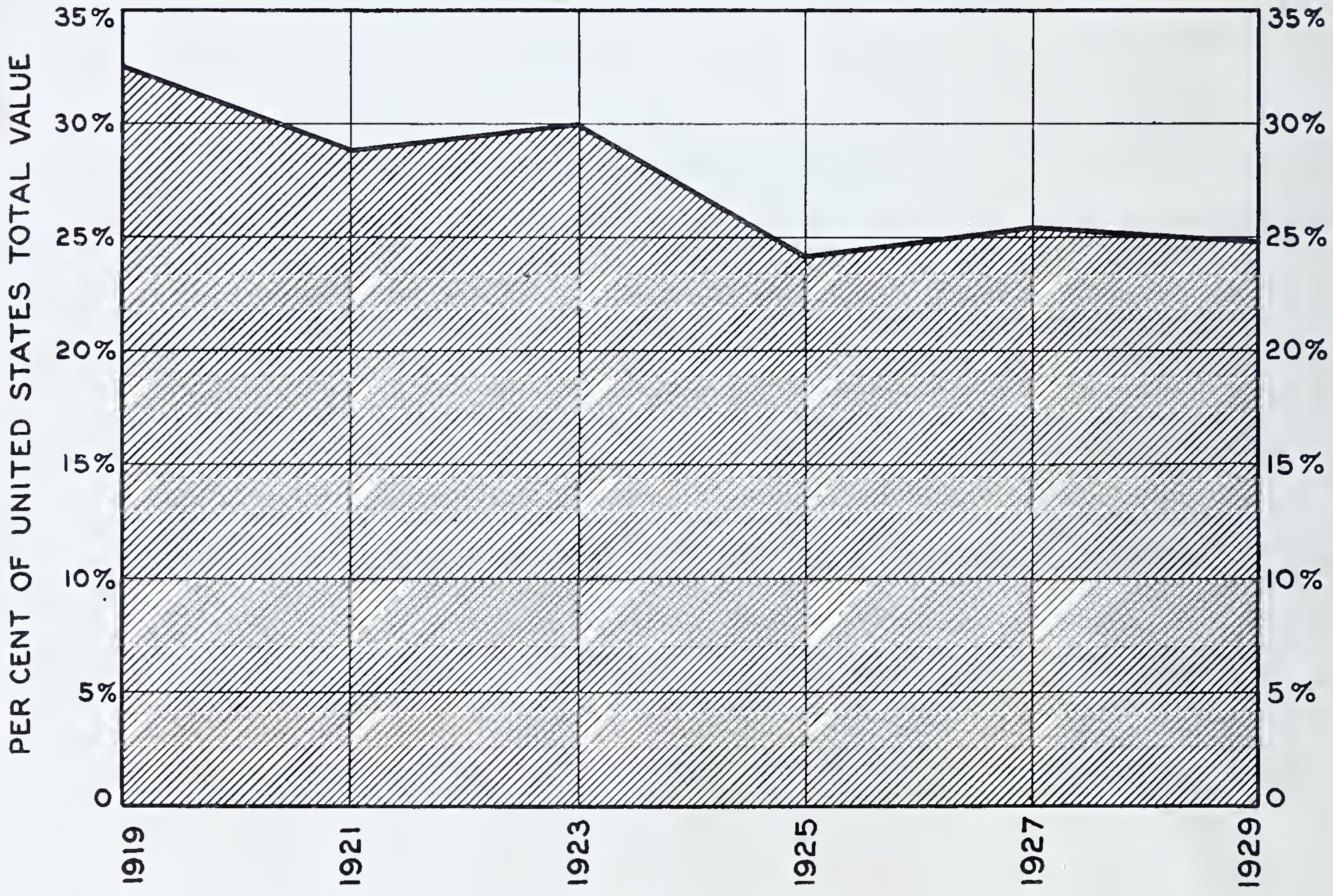
THE MINERAL INDUSTRIES OF PENNSYLVANIA

RELATIVE POSITION OF PENNSYLVANIA TO TOTAL UNITED STATES VALUE

Figure 1.

SUMMARY OF FINDINGS

The more important facts and conclusions set forth in this bulletin may be briefly summarized as follows:

1. The United States is the greatest mineral producing and processing country in the world, and, within the United States, Pennsylvania is by far the leading state in these activities.

2. Over two and one-half billion dollars are invested in Pennsylvania's mineral industries, and the value created annually by these industries amounts, ordinarily, to over a billion and a half dollars.

3. Pennsylvania's mineral industries employed about 600,000 persons in 1929, from which it may be estimated that these industries gave direct support to one-third of the State's total population. Indirectly, the mineral industries are of primary importance to a much larger proportion of the population, since they furnish materials for many manufacturing plants, freight for the railroads, and a vast market for the farmer and the merchant.

4. Pennsylvania has been losing ground in this group of industries so vital to the State's well being (Figure 1). In 1919 the value created by the principal mineral industries represented was 32½ per cent of the nation's total for these industries; in 1929 Pennsylvania contributed but 25½ per cent of the nation's total; and this decline is visible in almost every one of the State's mineral industries.

5. Pennsylvania's days of "skimming the cream", of making large profits from readily available and easily workable mineral resources, are over. Much of the State's most accessible mineral wealth has been used up, and hand in hand with decreasing accessibility is the factor of increasing competition.

6. More diligent search for new mineral deposits, development of better methods of producing and processing minerals, development of better means of utilization of minerals, development of new mineral uses, and studies of the economic problems of the mineral industries—all these are necessary if Pennsylvania is to continue to profit from this essential group of industries.

7. Research is essential in order to successfully combat the growing difficulties with which these industries are faced.

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PREFACE

> "Mineral Economics is the record of a battle, a battle between the growing difficulties of nature on the one hand and discovery, transport and technology on the other. How does the battle fare? . . . which side is winning, the natural conditions tending to increase costs or the man-directed conditions tending to reduce them?"—*Recent Social Trends.*

A period of depression, like a lull in a battle, offers an opportunity for the commanders to examine their positions, consolidate their gains, strengthen their lines, reconnoitre the enemy, and in general to plan and prepare for the next phase of the engagement.

Pennsylvania has so long occupied a position of supremacy in mineral industries that her place in the sun has been taken for granted by many. Modified economic conditions, the exhaustion of the better and more easily recoverable resources, and changing social trends are inexorable factors which must be reckoned with and met by the ingenuity of her people, if the Commonwealth is to remain supreme.

Discovery, the expansion of transport facilities and technology are the offsetting factors in favor of man in the battle against increasing costs; technologic advance has been of greatest importance during the past two decades and future progress will depend more and more upon technology.

Sound planning is necessary if the Commonwealth is to retain her leadership and the basis of such planning is knowledge.

Dr. Murphy's survey furnishes the necessary facts upon which to base a program of education and research on mineral industries and to unite the various branches of these industries in the common cause. The data are taken from many scattered sources and for the first time gathered together into one volume. This volume gives a picture of the battle field and shows the strengths and weaknesses along the far flung battle lines. Although originally designed to serve only as a basis for planning, it gives such an excellent overall view of the present position of the Commonwealth in the most important of its industrial activities that it seemed desirable to publish it in bulletin form.

Obviously a subject so broad as to cover the economic aspects of all the primary mineral industries—those which are concerned with the extraction and primary processing of mineral resources—cannot be treated fully in a single volume. The picture of each single industry is, therefore, too brief to furnish new information to those in the industry itself; it can, nevertheless, present to others some pertinent information on the industry. The whole volume should be useful in giving the layman a general picture of the important part played by mineral industries in the economic life of the Commonwealth, the trends in these industries as compared to their trends in the United States as a whole and some of the problems now before them.

The length of each chapter is not to be taken as a relative measure of the importance of its subject. In some cases more published information has been available than in others, a factor which also had to be taken into consideration.

The picture of the status of Pennsylvania's mineral industries as summed up in Figure 107 and in the text of the last chapter is a drab one indeed. In many industries the Commonwealth is losing ground and prompt action is necessary if she is not to recede from her enviable position. These industries are closely related and the welfare of one is not independent of progress in the others. **More than that, the prosperity of the entire state is in a large measure dependent upon the prosperity of these mineral industries. Buying power and not productive capacity is the critical factor in present day economics. Obviously the mineral industrial worker can do no buying—even of agricultural products — when he is out of employment. Inadequate returns to mines, quarries and mills affect whole communities and result in population shifts and capital migrations that must be reckoned with.**

There are some in Pennsylvania who appreciate the significance of the present trends and there are hopeful signs indicating intelligent efforts to combat them. One of these is the work started by the Greater Pennsylvania Council. Another is the support given to research on the part of certain associations representing whole industries. The results of such research programs are for the benefit of the industry as a whole and not for a single company, and thus wider dissemination of advantages is achieved.

A third hopeful sign is the interest aroused in schools of mineral industries and the growing support of their program. This program, which is functionally one of education and research, embraces three distinct types of subject matter, namely, (1) the earth sciences including geology, mineralogy, geography and related subjects, (2) mineral engineering including mining and quarrying and petroleum and natural gas engineering and (3) mineral technology including ceramics, metallurgy, fuel technology and petroleum refining.

A well established and properly equipped mineral industries experiment station becomes the logical agent for making such state investigations as require laboratory and research facilities.

During the present period of confusion, due largely to maladjustment between the rates of technologic and social advance, there are many who are disposed to place the responsibility for present economic conditions upon scientific achievement and to oppose further progress along these lines. On the other hand, the Research Committee on Social Trends "does not believe in a moratorium upon research in physical science and invention such as has been proposed. On the contrary, it holds that social invention has to be stimulated to keep pace with mechanical invention. What seems a welter of confusion may thus be brought more closely into relationship with the other parts of our national structure, with whatever implications this may hold for ideals and institutions."[1]

The problem is to synchronize and coordinate all the factors of our evolving society and in this a sound program of education and research is sure to play an important part.

A. W. Gauger, Member
Technical Advisory Committee,
The Greater Pennsylvania Council;
Director, Mineral Industries Research,
The Pennsylvania State College.

May 1, 1933.

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[1] Recent Social Trends, McGraw-Hill Book Company, New York, 1933, page XV.

SOURCES AND ACKNOWLEDGMENTS

This study of the economic aspects of the mineral industries of Pennsylvania was originally planned by the School of Mineral Industries of The Pennsylvania State College and initiated by the author when he joined its staff in 1931. It was completed in 1932 under the auspices of The Greater Pennsylvania Council.

The preparation of the bulletin required reference to many sources of material. Yet almost without exception these sources were general in character with only occasional references to Pennsylvania and its problems. It hardly seemed appropriate, therefore, to list them as a bibliography on the subject of Pennsylvania's mineral industries.

The principal sources of information were the various publications of the United States Bureau of Mines. Other important sources were the reports of the Pennsylvania Geological Survey; the annual industrial directories and productive industries reports of the Pennsylvania Department of Internal Affairs; the bulletins of the School of Mineral Industries of The Pennsylvania State College; the publications of the United States Census Bureau; annual volumes of ''The Mineral Industry'', a McGraw-Hill publication; and ''Minerals in Modern Industry'' by Dr. Walter H. Voskuil. A number of other books and various magazine articles were found to be of use in the preparation of certain sections of the bulletin. These are referred to by footnote in the various sections.

A number of persons have rendered valuable assistance to the writer either through furnishing information or through criticizing all or parts of the manuscript. The writer wishes to express his appreciation particularly to members of the Greater Pennsylvania Council and the Technical Advisory Committee of the Council for criticisms and suggestions covering the entire report; to officials of the Anthracite Institute for reading and criticizing the chapter dealing with the Anthracite Industry; and to the various members of the staff of the School of Mineral Industries of The Pennsylvania State College for many helpful suggestions and for criticism of the various chapters.

The Author

CONTENTS

Page
SUMMARY OF FINDINGS iii
PREFACE iv
SOURCES AND ACKNOWLEDGMENTS vi

CHAPTER I
PREVIEW OF THE MINERAL INDUSTRIES 1

CHAPTER II
COAL 4
  Introduction 4
  Importance of the coal industry 4
  Ranks of coal 4
  The anthracite and bituminous coal industries contrasted 5

CHAPTER III
THE ANTHRACITE INDUSTRY 6
  Introduction 6
  Organization of the anthracite industry 6
  Production and preparation of anthracite 7
    Mining of anthracite 7
    Preparation of mined coal 8
    Culm bank recovery 8
    Dredging 9
    Some problems connected with anthracite mining 10
      Surface subsidence 10
      Waste disposal and stream pollution 10
  Utilization and marketing 10
    Steam sizes 11
    Sizes finer than "steam" 13
      The fuel briquet industry 13
    The domestic market 14
    Effect of recent strikes 14
    Competition with other fuels for domestic market 15
      Fuel oil 15
      Coke 15
      Gas 15
      Fuel briquets 16
      Imported anthracite 16
      Domestic hard coal mined outside of Pennsylvania 16
      Hydroelectric power 17
      Bituminous coal 17
      Efforts to meet competition 17
        The Anthracite Service 17
        Research 17
        The Anthracite Bureau of Information 18
        Inspection service 18
        Other activities of the anthracite operators 18
    Regional consideration of anthracite markets 18
      The New England market 18
      The Middle Atlantic States market 20
      Markets west of Pennsylvania 20
      Export trade in anthracite 21
    Efforts of industry to meet market needs 21
    Future markets 21
  Freight rates 21
  Taxation of the anthracite industry 22
  Major problems of the anthracite industry 22
  Future of the anthracite industry 23

CHAPTER IV
THE BITUMINOUS COAL INDUSTRY 25
  Introduction 25
  The mining of bituminous coal in Pennsylvania 27
    Mining methods 27
    Wastes in production 28
    Stream pollution 29

CHAPTER IV

THE BITUMINOUS COAL INDUSTRY—(Continued)

Page

- Ownership of mines ... 29
- Unions and strikes ... 29
- Preparation of bituminous coal for market ... 30
  - Sizing ... 30
  - Cleaning ... 30
  - Coal pulverization ... 31
- Trends in coal production ... 32
- Utilization of bituminous coal ... 32
  - Disposal of coal at mines ... 32
  - Consumers of bituminous coal in Pennsylvania ... 32
- The marketing of bituminous coal ... 33
  - Markets in the United States by uses ... 33
    - Coal market in the iron and steel industry ... 33
      - Details of the coke industry ... 34
      - Possible future migration of iron and steel industry ... 34
    - Coal market presented by railroads ... 35
    - Heating of houses and other buildings ... 36
    - Bunker-fuel market ... 37
    - Electric utilities market ... 37
    - General manufactures as a market for coal ... 38
    - Market for coal in gas manufacture ... 38
    - Coal used at mines for power and heat ... 38
    - Foreign trade ... 38
  - Movements of coal from Pennsylvania bituminous coal area ... 38
    - Westward movements by all-rail haul and by river barge ... 38
    - The lake-cargo bituminous coal movement ... 39
    - All-rail movement to the north and east ... 41
    - Tidewater bituminous coal shipments ... 41
      - Export trade ... 43
  - Summary by Pennsylvania producing districts ... 44
    - Western Pennsylvania ... 44
      - Pittsburgh district ... 44
      - Greensburg-Westmoreland, Latrobe, and Ligonier districts ... 45
      - Connellsville district ... 45
    - Central Pennsylvania ... 45
    - Somerset-Meyersdale district ... 47
  - Competitive position of bituminous coal ... 47
  - Tariffs ... 47
  - Seasonal character of bituminous coal consumption ... 48
  - Storage of coal ... 48
  - The selling of coal ... 49
- Transportation or getting coal to market ... 49
  - Methods ... 49
  - Freight rates ... 50
- Taxation ... 50
- The plight of bituminous coal ... 50
- The future of the bituminous coal industry in Pennsylvania ... 51
  - Future shifts in the industry ... 51
  - Conservation ... 51
  - The future of coal mining communities ... 51

CHAPTER V

COAL PROCESSING ... 52

- High-temperature carbonization ... 52
  - The coke industry ... 52
    - Beehive coke ... 52
    - The shift to by-product coking ... 54
    - By-product coke ... 55
      - Coal requirements ... 55
      - Production of by-product coking coal in Pennsylvania ... 56
      - Types of by-product plants ... 56
      - Location of plants ... 56
      - The by-products ... 56
      - Coke breeze ... 58

CHAPTER V

COAL PROCESSING—(Continued)

Page

Utilization and marketing of coke and breeze 58
  Consumption of coke by iron furnaces 58
  Use of coke by foundries and for other industrial uses 60
  Domestic use of coke 60
  Consumption of breeze 61
Transportation 61
Foreign trade in coke 61
Future of the coke industry 62
The manufactured gas industry 62
  The uses of manufactured gas 62
  Relation of the industry to by-product coking 62
  The manufactured gases 63
    Coke-oven gas 63
    Coal gas 63
    Blue water gas 63
    Carburetted water gas 64
    Producer gas 64
    Blast-furnace gas 64
    Oil gas 64
    Average manufactured gas 64
  Importance of the manufactured gas industry 64
  Location of industry 65
  Consumption of gas-making materials and fuels 65
  Products of the manufactured gas industry 65
  Purchase of gas by manufactured gas companies 65
  Where is manufactured gas consumed? 66
  Transportation 66
  Problems and trends of the industry 66
    Seasonal demand 66
    The nature of the gas delivered 66
  Future of the industry 66
Low-temperature carbonization 66
Liquefaction 67

CHAPTER VI

THE PETROLEUM INDUSTRY 68
  Introduction 68
  History of the petroleum industry in Pennsylvania 69
  "Pennsylvania-grade" crude oil 70
  Production 70
    Exploration 70
    Location of production 70
    Methods of producing petroleum in Pennsylvania 72
      Ordinary drilling 72
      Depth of wells 72
      Secondary methods 72
        Water flooding 73
        Vacuum method 73
        Repressuring with air and gas 74
        "Oil Mining" 74
    Characteristics of Pennsylvania production 74
    Costs of production 74
    Wastes in production 75
    Purchase of crude oil 75
    The uses of petroleum 75
    Markets for crude petroleum 75
    Prices of "Pennsylvania-grade" crude petroleum 76
    Overproduction 76
    Pro-ration 76
    Conservation 77
    Tariff on imported crude oil 77
    The future of petroleum production in Pennsylvania 77
    The last stage of production 78

CHAPTER VI

THE PETROLEUM INDUSTRY—(Continued)

Page
Transportation 78
  Pipe lines 78
  Losses in transportation 79
Petroleum refining 79
  The refining process 79
  The materials used in the industry 80
  Importance 80
  Transportation of refinery products 80
  Products of the industry 80
  Two groups of refineries in Pennsylvania 80
    The western group 80
      Fuels used 81
      Source of crude 81
      Products resulting 81
    The eastern group 83
      Source of crude 83
      Fuels used 83
      Products resulting 83
  Competitive position of the products of petroleum refining 83
After petroleum, what? 83

CHAPTER VII

THE NATURAL GAS INDUSTRY 85
  Introduction 85
  Development of Pennsylvania's natural gas industry 85
  Importance of Pennsylvania's industry today 85
  Location of the industry in Pennsylvania 86
    The Tioga County Field 87
  Methods of production 88
  Preparation for market 88
    The natural gasoline industry 88
    Compression 90
  The uses of natural gas 90
  Distribution of natural gas 91
    Long-distance pipe lines in relation to Pennsylvania and its natural gas industry 92
    Other distribution problems 93
  Marketing of natural gas 93
  Changes in Pennsylvania's importance as a natural gas producer 94
  The waste of natural gas 95
  Major problems of the industry 95
  Future of natural gas industry of Pennsylvania 96

CHAPTER VIII

THE COMMON ROCK INDUSTRIES OF PENNSYLVANIA 98
  Introduction 98
  The producing industries 100
    Limestone 100
      Location of quarries 100
      Mining methods 101
      Uses of limestone 101
      Value 101
      Markets 102
        Limestone market in the cement industry 102
        The fluxing-stone market 102
        The concrete and road metal market 103
        Limestone for the lime industry 103
        The building-stone market 103
        Agricultural limestone 103
        Other markets for limestone 103
      Recent trends in production and value 103
      Tariff 104
      Dolomite, marble, and marl 105
    Sand and gravel 105
      Uses of sand and gravel produced in Pennsylvania 105

CHAPTER VIII

THE COMMON ROCK INDUSTRIES OF PENNSYLVANIA—(Continued)

Page
- Value ... 106
- Mining methods ... 106
- Location and development of sand and gravel industry ... 106
  - Building and paving sand and gravel ... 106
  - Glass sand ... 107
  - Molding sand ... 108
  - Silica sand ... 108
- Recent trends in production and value ... 108

Clay ... 108
- Uses of clay ... 108
- Mining methods ... 109
- Areas of production in Pennsylvania ... 109
  - Fire clays ... 109
  - Kaolin and white clays ... 110
  - Clays and shales ... 110
- Markets ... 110
  - Tariff ... 110
- Shale ... 110
- Clay and the clay-product industries ... 110

Sandstone ... 110
- Uses of Pennsylvania sandstone ... 110
- Value ... 110
- Tariff ... 110
- Varieties of Pennsylvania sandstone ... 111
  - Bluestone ... 111
  - Ganister ... 111
  - Other sandstone and quartzite ... 112
- Recent trends in production and value ... 112

Trap rock and granite ... 112
- Trap rock ... 113
  - "Black Granite" for monuments ... 114
  - Recent trends in production and value ... 115
- Granite and related rocks ... 115
  - Recent trends in production and value ... 116
- Tariff ... 117

Slate ... 118
- Location of production in Pennsylvania ... 118
- Methods of mining ... 118
- The uses of slate ... 118
- Value ... 119
- Markets ... 119
  - Color as a factor in marketing ... 121
- Recent trends in production and value ... 121
- Freight rates ... 121
- Imports and exports ... 121
- Problems ... 122

"Miscellaneous stone" ... 122

Minor common rock industries ... 122
- Serpentine ... 122
- Talc ... 122
- Feldspar ... 122
- Mineral paints and mortar colors ... 123

Pennsylvania as a source of building stone ... 123
- Present production ... 123
- Pennsylvania's place as a producer of building stone ... 123
- The future of Pennsylvania's building stone industry ... 124

Rock cutting, shaping, and finishing industries ... 125

Transportation ... 125

Future of the common rock industries ... 126

CHAPTER IX

THE CLAY-PRODUCTS INDUSTRIES ... 127
- Introduction ... 127
- Clay-products industries other than pottery ... 127

CHAPTER IX

THE CLAY-PRODUCTS INDUSTRIES—(Continued)

Page
- Clay refractories ... 127
- Brick (other than fire brick) ... 127
  - Cost items ... 128
  - Markets ... 129
  - Competition from concrete ... 129
- Other products ... 130
- Recent trends in production and value ... 130

Pottery ... 130
- Location of the industry ... 131
- Trend toward modernization ... 131
- Recent trends in production and value ... 131

Future of the clay-products industries in Pennsylvania ... 131

CHAPTER X

NONCLAY REFRACTORIES ... 132
- Introduction ... 132
- Silica brick ... 132
- Magnesite and chrome refractories ... 133
- High-temperature cements ... 133
- Abrasives and grinding wheels ... 133

CHAPTER XI

THE LIME INDUSTRY ... 134
- Introduction ... 134
- Location of production in Pennsylvania ... 134
- Lime plants and lime manufacture ... 134
  - Hydrated lime vs. quicklime ... 134
  - Raw material ... 135
  - Fuel ... 135
- The uses of lime ... 135
  - Building uses ... 136
  - Agricultural uses ... 136
  - Chemical uses ... 136
- The markets for lime ... 137
- The value of lime ... 138
- Recent trends in production and value ... 139
- Exports and imports ... 139
- Future of Pennsylvania's lime industry ... 139
- Gypsum plaster ... 139

CHAPTER XII

THE PORTLAND CEMENT INDUSTRY ... 140
- Introduction ... 140
- Development of the industry ... 140
- Pennsylvania's place as a cement producer ... 140
- Importance of the cement industry to Pennsylvania ... 140
- The producing regions ... 140
  - The Lehigh district ... 140
  - Other cement regions ... 141
- Materials used in Portland cement manufacture ... 141
  - Raw materials ... 141
  - Fuels ... 142
- The manufacturing process ... 143
- Uses of cement ... 143
- The price of Portland cement ... 143
- Portland cement markets ... 144
  - Cement markets for the Lehigh district ... 144
    - Competition from foreign cement ... 144
  - Cement markets for the other Pennsylvania plants ... 145
  - Per capita consumption in Pennsylvania ... 145
  - Seasonality of the demand for cement ... 145
  - Possible cement expansion ... 145
- Problems of the industry ... 146

CHAPTER XIII

Page

THE GLASS INDUSTRY ... 147
  The glass-making process ... 147
  Development of glass manufacture ... 147
    The American glass industry before 1870 ... 147
    The American glass industry since 1870 ... 148
      The regenerative reverberatory furnace ... 148
      The continuous tank ... 148
      Glass-making machinery ... 148
        Mechanization of bottle manufacture ... 148
        Machinery in the window glass industry ... 148
        Machinery for making other glassware ... 148
      Transition stage of glass industry ... 148
      Effect of the World War ... 148
      Specialization and large-scale production ... 148
  The present-day glass industry of Pennsylvania ... 149
    Branches of the glass industry ... 149
    Raw materials ... 149
    Fuels ... 149
    Type of furnace ... 149
    Recent trends in production and value ... 150
    Location of industry in Pennsylvania ... 151
      Western Pennsylvania ... 151
      Southeastern Pennsylvania ... 152
      Other glass-manufacturing plants in Pennsylvania ... 152
  Future of the glass industry ... 152
  Porcelain enamels ... 152

CHAPTER XIV

THE IRON AND STEEL INDUSTRY ... 153
  Introduction ... 153
  The method of manufacture ... 153
    The ore ... 153
    Pig iron ... 154
      Production of pig iron ... 154
      Disposal of pig iron ... 154
    Cast iron and wrought iron ... 154
      Cast iron ... 154
      Wrought iron ... 154
    Steel ... 154
      The manufacture of steel ... 154
        The Bessemer process ... 154
        The open-hearth processes ... 155
        Electric and crucible steel ... 155
        The role of ferro-alloys ... 155
        The final stages of steel manufacture ... 156
  Development of the iron and steel industry ... 156
    The iron industry ... 156
      The iron industry at Lancaster ... 156
      Separation of smelting and rolling ... 156
      Movement across the Alleghenies ... 156
      Early iron industry of Pittsburgh ... 156
      Growth of demand in the East ... 158
      The anthracite furnaces ... 158
      Coke as a blast-furnace fuel ... 158
      Lake Superior ore ... 158
      The growth of Pittsburgh as an iron center ... 158
    The rise of steel ... 158
      The demand for a better product ... 158
      The Bessemer process ... 158
      Open-hearth steel ... 158
  Recent growth of the industry ... 159
  Integration of the industry ... 160
  Steel-consuming industries ... 160

CHAPTER XIV

THE IRON AND STEEL INDUSTRY—(Continued)

Page
Location of the iron and steel industry in the United States 160
  Iron ore 161
  Pig iron 161
  Steel manufacture 161
The iron and steel industry in Pennsylvania 161
  Eastern Pennsylvania 161
    Causes of localization 164
    Present distribution of plants 164
    Companies operating 164
    Materials used in the industry 164
      Iron ore 164
      Iron and steel scrap 166
      Limestone 166
      Fuel 166
      Ferro-alloys 166
      Refractories 167
    Production trends in eastern Pennsylvania 167
    Markets 168
      Domestic markets 168
      Foreign markets 168
  Western Pennsylvania 169
    Causes of localization 169
    Distribution of plants 171
    Operating companies 171
    Sources of materials used in the industry 171
      Iron ores and scrap 171
      Coal 171
      Gas 171
      Limestone 171
      Ferro-alloys 171
      Refractories 171
    Pittsburgh—the leading iron and steel center of western Pennsylvania 171
      Transportation 171
      Topography's limitations upon growth of the industry 172
      The market for Pittsburgh's iron and steel 172
      Advantages and disadvantages of the Pittsburgh iron and steel center 172
    Recent trends in the iron and steel industry of western Pennsylvania 174
      Pig iron 174
      Steel ingots and castings 174
      Finished rolled iron and steel 175
      General conclusions from trend analysis 175
Iron and steel prices 177
Foreign trade in iron and steel 177
  Iron ore 177
  Iron and steel 177
    Imports 177
      Protection from foreign iron and steel 177
    Exports 177
  The ferro-alloys 177
    Imports 177
      Tariff on ferro-alloys 177
    Exports 178
The future 178

CHAPTER XV

OTHER METAL INDUSTRIES 179
  Introduction 179
  Production of the ores of nonferrous metals 179
  Reducing, refining, and alloying 179
    The primary zinc industry 179

CHAPTER XV

OTHER METAL INDUSTRIES—(Continued)

Page
- Uses of zinc 179
  - Slab zinc 179
  - Other uses of zinc 179
- The present zinc industry in the United States 179
- Recovery of zinc from its ores in Pennsylvania 179
  - Location of the state's industry 180
  - Development of the industry in Pennsylvania 180
  - Localization of the industry 180
  - Organization of the industry 181
  - The trend in primary zinc production 181
  - Future of Pennsylvania's industry 181
- The production of secondary metals 181
  - Secondary zinc 181
  - Other secondary metals 181
  - The value of secondary metals 181

CHAPTER XVI

THE FUTURE OF PENNSYLVANIA'S MINERAL INDUSTRIES 182
- Fundamental problems 182
  - Freight rates 182
  - Taxation 182
  - Tariffs 182
  - Overproduction 183
  - Conservation 183
- General trends 183
- Needs of the mineral industries 183
  - Cooperation versus competition 185
- The future 185

I

PREVIEW OF THE MINERAL INDUSTRIES

Extraction of minerals from the ground and the processing of some of these minerals have been of steadily increasing importance to man since the beginning of recorded history. As civilization has advanced, so has the consumption of minerals. Today minerals in some form are used in the production of almost every economic product, and play a well-nigh unbelievably important role in world affairs.

Particularly striking is the way in which mineral use has been increasing. Few realize "that in a hundred years the output of pig iron, copper, and mineral fuels has increased a hundred fold; that more mineral resources have been mined and consumed since the opening of the century than in all preceding history; that in the United States more minerals have been mined and consumed in the last twenty years than in its preceding history; that the per capita consumption of minerals in the United States has multiplied fifteen times in forty years."[1]

The United States is the greatest mineral producing and processing[2] country in the world, and, within the United States, Pennsylvania is by far

TABLE I

PENNSYLVANIA'S EXTRACTIVE MINERAL INDUSTRIES[a]

Industry	Investment 1930	Employment 1929	Value of Products, 1929
Bituminous Coal	$475,000,000	130,000	$258,607,000
Anthracite	445,000,000	158,000	385,643,000
Common Rocks	50,000,000b	c	65,000,000b
Petroleum	c	c	44,800,000d
Natural Gas	171,000,000	8,600	28,189,000d
Iron Ore	9,500,000	450	2,383,000

a Investment figures are from 1930 Report on Productive Industries, Pennsylvania Department of Internal Affairs; employee figures are from State and other sources; value of products figures are based on United States Bureau of Mines data.

b Partly estimated by the author.

c Data not available.

d At wells.

TABLE II

PENNSYLVANIA'S PRIMARY PROCESSING MINERAL INDUSTRIES[a]

Industries	Investment[a] 1930	Employees 1929	Payroll 1929	Total value of Products 1929	Value added by Manufacture 1929
Metallurgical Industries					
Iron and Steel					
Blast Furnaces	$750,000,000	8,906	$16,000,861	$280,711,528	$45,668,403
Steel Works and Rolling Mills		159,621	287,303,600	1,212,876,856	503,029,271
Nonferrous Metallurgy	35,000,000[b]	10,000[b]	17,000,000[b]	100,900,580[b]	37,632,690[b]
Ceramic Industries					
Clay products, pottery and non-clay refractories	85,000,000	21,456	28,159,634	67,634,597	48,307,409
Cement	80,000,000	8,834	15,286,648	59,420,045	38,299,474
Glass	68,000,000	20,095	28,153,245	81,050,092	50,907,037
Lime	6,806,000	1,583	1,990,049	5,990,525	4,057,333
Emery and other abrasive wheels	1,713,000	790	1,258,126	3,924,138	2,804,557
Coal Processing					
Coke, not including gas-house coke	71,000,000	6,713	11,217,920	115,345,477	38,622,904
Manufactured gas	192,000,000	4,767	7,624,470	38,241,814	25,684,848
Petroleum Refining	222,000,000	9,495	16,608,214	243,258,869	48,215,658
Others	10,000,000[c]	5,000[c]	6,000,000[c]	15,000,000[c]	10,000,000[c]

[a] Investment figures are from 1930 Report on Productive Industries, Pennsylvania Department of Internal Affairs; other data from United States Census.

[b] Partly estimated by the author.

[c] Estimated by the author.

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[1] Leith, C. K., World Minerals and World Politics, New York, 1931, pp. 3-4.

[2] The present report deals with the production of mineral raw materials (extraction) and with the earlier stages of their processing. These earlier processing stages have sometimes been referred to as "primary processing". They include the separation of metals from their ores, the treating of raw fuels, and similar operations; but exclude the final stages of manufacturing processes such as those by which metal bars, plates, etc., are made into various kinds of machinery.

the leading state in these activities. Viewed from another angle, the importance of mineral industries to the state of Pennsylvania can hardly be over-emphasized. Investment in these industries within the State totals well over two and one-half billion dollars, and the value annually created amounts to a billion and a half (Tables I, II, and III). Although exact data are not available as to the taxes contributed, the aggregate is undoubtedly very large. In terms of persons employed, the mineral industries are similarly outstanding. In 1929 mining and the primary processing of minerals in the State employed about 600,000 persons. It is of interest to note that in the same year agriculture, which outranks mining in most states, employed only 251,000 in Pennsylvania, or less than were employed by the State's coal mining industry.

Though but the thirty-second state in land area, Pennsylvania is second in population and second in wealth, the seeming anomaly being chiefly explainable by the State's mineral resources, with resultant mining, processing, and related industries. Such a relationship is to be seen, too, in the population map (Figure 2). Of the three spots of greatest population density, two, Allegheny County and Lackawanna County, are dominated by mineral industries.

The dominance of mining and primary processing of minerals in Pennsylvania extends far out-

TABLE III
GENERAL SUMMARY OF PENNSYLVANIA'S MINERAL INDUSTRIES

1. Extractive Industries:	
Value of products, 1929	$784,622,000
Number of employees[a], 1929 (more than)	300,000
Investment[b], 1930 (more than)	$1,150,500,000
2. Primary Processing Industries:	
Investment[a], 1930	$1,521,519,000
Number of employees[a], 1929	257,000
Payroll[a], 1929	$436,000,000
Total value of products[a], 1929	$2,224,000,000
Value added by manufacture[a], 1929	$853,000,000
3. Summary of all Mineral Industries:	
Value created, 1929[c]	$1,640,000,000
Investment, 1930 (estimate)	$2,800,000,000
Number employees, 1929 (estimate)	600,000

[a] Partly estimated by the author.

[b] Figure given does not include investment in production of petroleum, there being no data available on this point.

[c] Total value of extractive products plus value added by manufacture in primary processing industries.

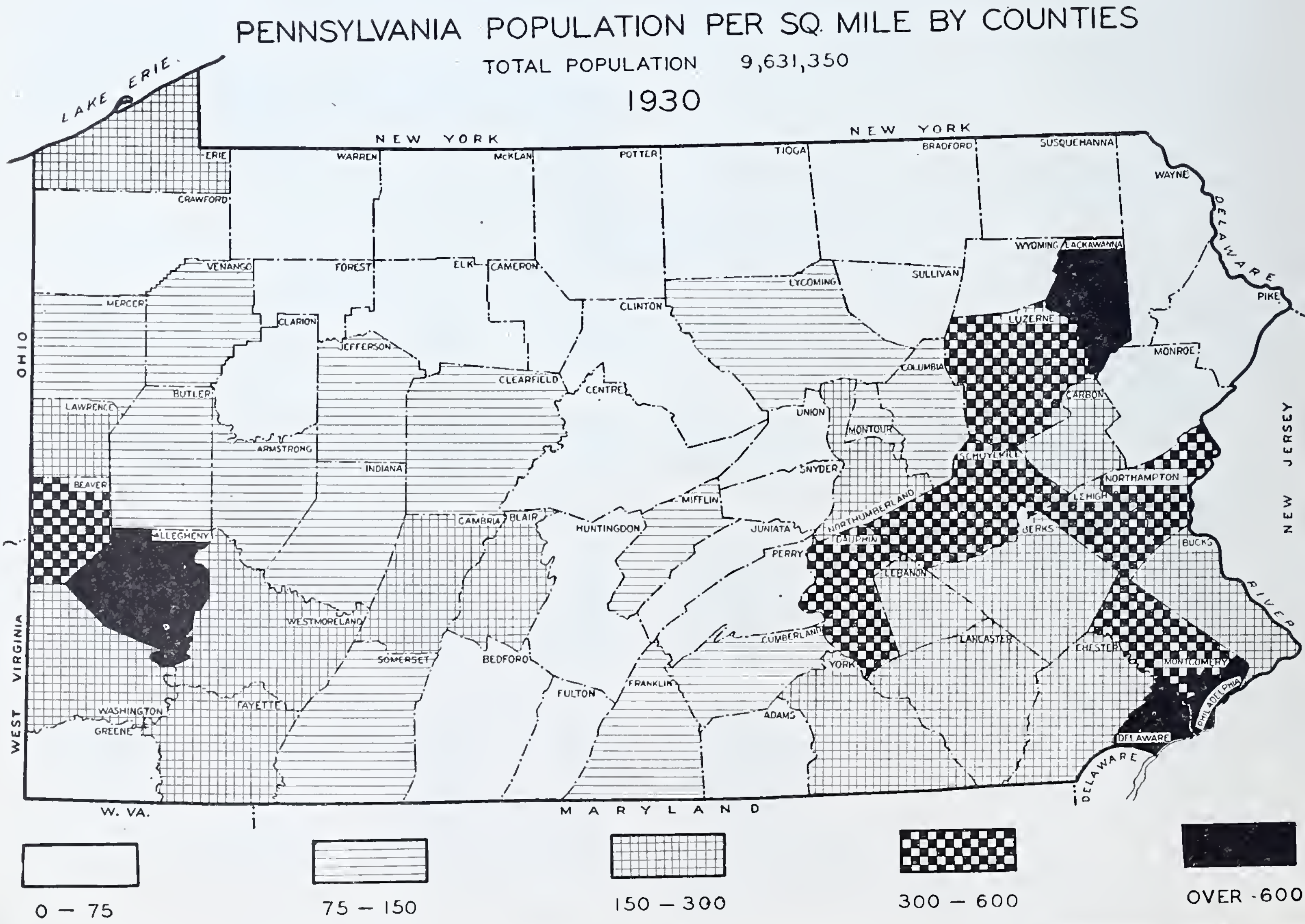

Figure 2. Distribution of population in Pennsylvania, 1930. From "Population Trends" by Greater Pennsylvania Counc

side of these industries themselves. To many industries the products of the steel mill, of the by-product plant, or of other primary processing plants are raw materials. Such plants, making direct use of the products of primary processing of minerals, are numerous in Pennsylvania. Some of these plants make machinery to be used in mining and processing minerals and hence are doubly tied to the mineral industries. Scarcely less dependent are certain types of manufacturing plants, such as the silk mills of the anthracite region, which rely upon the excess of female labor characteristic of mineral industries regions.

The influence of the mineral industries in Pennsylvania is by no means limited to mining and manufacturing. Railways depend upon coal for their power, while minerals constitute over three-fourths of their tonnage. Agriculture is affected because the workers in mining, mineral industries, and related activities constitute a large non-food producing element of the State's population which must be fed. Wholesale and retail trade are similarly affected, as is nearly every other economic activity. **Truly, Pennsylvania's mineral resources have been the very heart of her economic development.**

Many states which have prominent mineral industries owe their development to metallic minerals. Not so Pennsylvania. The State has gained its leading position in mineral industries because of its nonmetals, particularly the mineral fuels (Table I), and in the pages that follow it will be noted that fuels are the central theme—their production constituting several large extractive industries, and their availability accounting for the presence of the principal mineral processing industries.

Finally, Pennsylvania has played a part in the nation's mineral industries which production figures fail to indicate. Mineral industries workers trained in the State have spread far and wide over the country making use of experience gained and capital accumulated in Pennsylvania in the development of mineral industries elsewhere.

II

COAL

Introduction

"To many, the word 'coal' conjures up a mental picture of piles of black lumps, or of soot, smoke and ashes; but to one who really knows and appreciates coal, it outrivals the tarnished lamp which Aladdin rubbed with such amazing consequences. The business man knows coal as the driving force of industry. To the chemist, it is the source of dyes, explosives, antiseptics, fertilizers, perfumes, and of myriad chemical products. And the geologist sees in it the altered, but yet recognizable, remains of great forests and canebrakes, which flourished on the swampy lowlands of the past."[1]

A great many countries are coal[2] producers, but the United States, leading them all, produced, in 1931, 32 per cent of the world's total. Similarly, Pennsylvania is the leading coal producing state, accounting for 36 per cent of the United States coal tonnage in 1930 and for a similar percentage in 1931.

Importance of the Coal Industry

The importance of the coal industry to the United States and to Pennsylvania is difficult to overemphasize. In 1931 coal supplied, according to the United States Bureau of Mines, about 56½ per cent of the energy requirements of the United States, and to Pennsylvania coal is of much greater importance than it is to the country as a whole. It is the foundation of the industrial development of a great industrial state. According to the 1930 Census, coal mining employs about 290,000 persons in Pennsylvania. When the dependents of these employees are considered, it is evident that between 1,000,000 and 1,500,000 persons in the State are directly dependent upon coal mining. Moreover, many more than are employed in coal mining are employed in manufacturing, transportation, and other activities closely related to the presence of coal. Some of the manufacturing activities, such as coke making, use coal as a raw material; but many of the others depend almost as directly upon coal, and would not be located in the State were it not for the presence of a coal supply. The iron and steel industry is of this character.

Ranks of Coal

Coals are commonly classified on the basis of the proportions of fixed carbon, volatile matter (or gases), and water which they contain. The term "rank" is used to designate these differences, a high-rank coal being one that has a high percentage of fixed carbon and a low percentage of volatile matter and moisture. Two main ranks of coal are important in Pennsylvania—anthracite, which is popularly known as "hard" coal, and bituminous or "soft" coal. Anthracite is very high in rank, which means that it is almost all fixed carbon. Since anthracite has so little volatile matter, it burns without smoke. Bituminous coal is of lower rank than anthracite, that is, it has more volatile matter in proportion to fixed carbon. It follows that bituminous coal burns with greater ease but gives off smoke.

From Figure 3 it may be seen that the percentage of fixed carbon in the coals decreases from east to west in Pennsylvania, the highest rank coal, anthracite, being found in the east. The term "anthracite" is generally used to designate both true anthracite such as is found in the various anthracite fields of eastern Pennsylvania and semi-anthracite, found, for instance, in Sullivan County. Semi-anthracite has a lower percentage of fixed carbon than anthracite, but is, nevertheless, practically smokeless. The same is true of the low-volatile bituminous coal, which is just below semi-anthracite in rank; and for that reason this low-volatile bituminous coal, occurring in isolated basins such as the Broad Top Field of northeastern Bedford County and southern Huntingdon County and along the eastern edge of the main area of bituminous coal in the State, competes with anthracite and semi-anthracite for the domestic market, although it is highly prized, also, as a steam coal and has a variety of other uses. Lower ranks of bituminous coal, though they all find considerable domestic use, are smoky and give rise to the "smoke nuisance" of our cities.

Medium-volatile coals, the volatile matter ranging from 21 to 30 per cent, lie in a belt next to the west, in Indiana, southeastern Jefferson, central and eastern Westmoreland, and eastern Fayette counties. They are used principally for steam purposes for which they are well adapted. These medium-volatile coals are particularly well suited to the making of beehive coke; but the by-product

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[1] Thom, W. T., Petroleum and Coal—The Keys to the Future, Princeton, 1929, p. 13.

[2] Unless otherwise qualified, the word "coal" as used in this chapter refers to all ranks of coal considered together. It includes, therefore, both bituminous coal and anthracite.

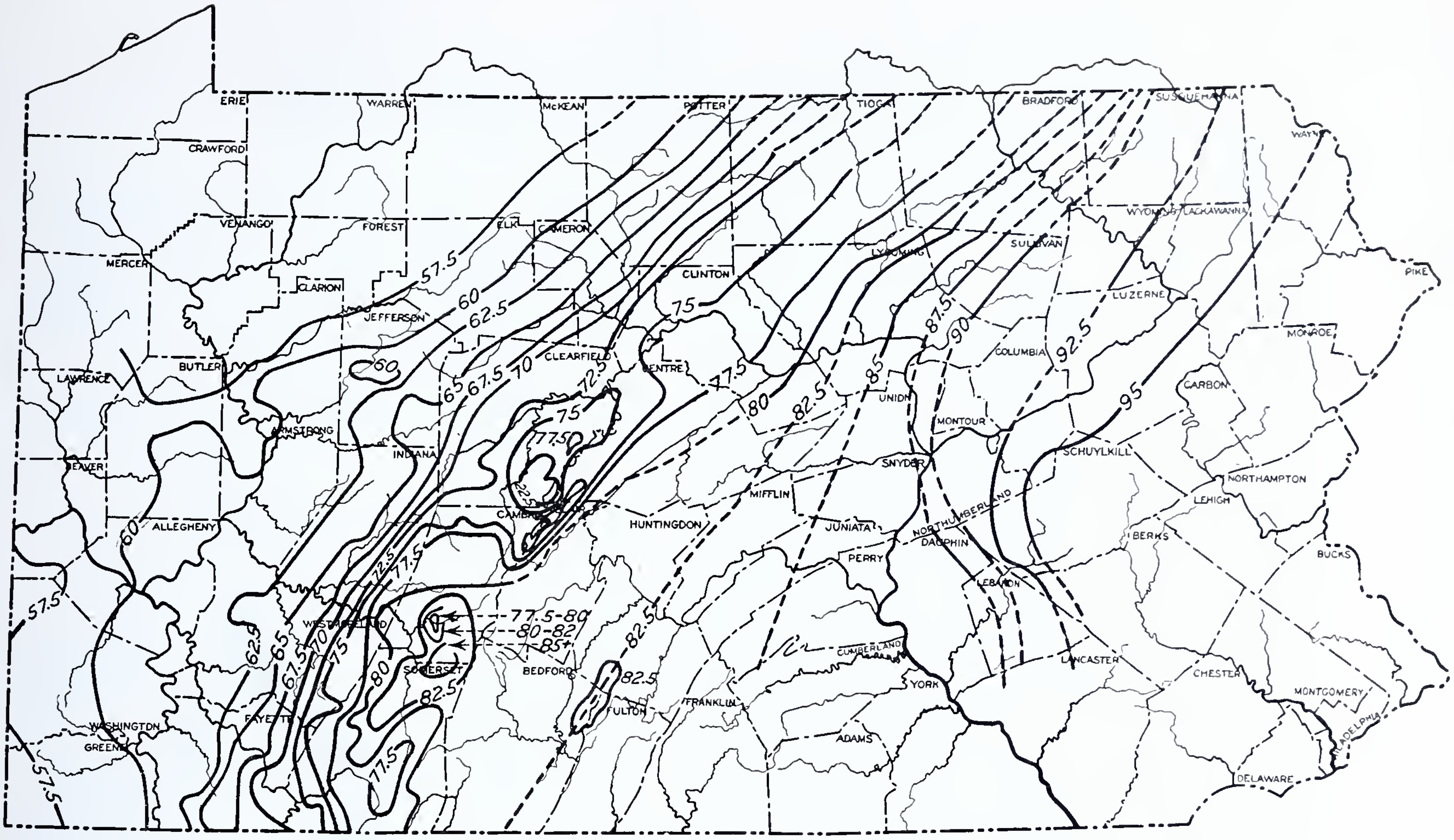


Figure 3. Isocarb map, showing increase in percentage of fixed carbon in coal from west to east. Conversely, of course, volatile matter increases from east to west. (Courtesy of Pennsylvania Geological Survey.)

coke industry, which has largely replaced beehive coking, uses low-volatile, medium-volatile and high-volatile coals, often mixed, the ability to "coke" bearing, apparently, little relation to the exact rank of the bituminous coal.

High-volatile, and hence low-rank, bituminous coals, sometimes called "gas coals", occur, for the most part, west of the medium-volatile coals in Pennsylvania. The coals of western Fayette County, of Greene and Washington counties, of Allegheny County, and of Clarion County are of this character. At present these coals, of which the Pittsburgh bed is the most illustrious member, serve four principal uses—steam making, including locomotive use, coke making, gas making, and household use.

The Anthracite and Bituminous Coal Industries Contrasted

The anthracite and bituminous coal industries, though they both deal with coal, differ in so many ways as to justify separate treatment. Anthracite is primarily a domestic fuel, and bears little relation to the manufacturing development in which bituminous coal is so important. Anthracite reserves are distinctly limited as compared with the country's reserves of bituminous coal. The anthracite industry of the United States is almost entirely confined to a part of one state (93 per cent of the total coming from 4 counties in eastern Pennsylvania) and thus, as a producing industry, is of only local concern; the bituminous coal industry, spread over many states and countries, is by mere areal extent of international importance. These are but a few of the many contrasts between the two industries.

The tonnage of bituminous coal produced in the United States in 1931 was six and one-half times as great as the anthracite tonnage for the same year, but the value of the bituminous coal was only about two times that of anthracite. In Pennsylvania, the home of the anthracite industry, the two are on much more even terms. The 1931 tonnage of bituminous coal produced in the State was 1.6 times that of anthracite, but the total value of the latter was twice that of the State's bituminous coal production. The anthracite industry employed 22 per cent more men during 1930 than did the bituminous coal industry of the State.

It should be remembered in making these comparisons that Pennsylvania is primarily an industrial state, and that bituminous coal has formed the foundation for her industrial development. Considered from this angle, the bituminous coal industry of the State is of vastly greater importance than the anthracite industry.

III

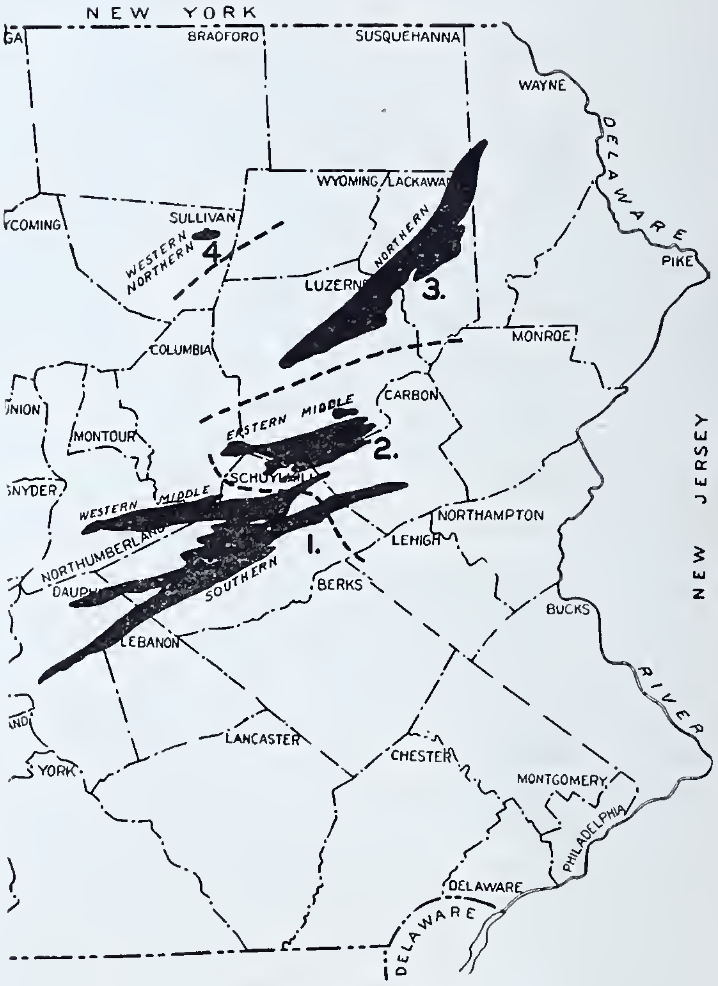
THE ANTHRACITE INDUSTRY

Introduction

The mining and preparation of anthracite is peculiarly a Pennsylvania industry. True, the bituminous coal mined in the State is of greater bulk, but other states and countries produce large quantities of bituminous coal. In anthracite production, on the other hand, Pennsylvania stands almost alone, accounting for over 99 per cent of the United States total and far exceeding the production of all other countries combined.

Besides natural interest in a home industry in which the State is paramount, there are several more practical considerations upon which Pennsylvania's concern in the anthracite industry is based. In value, the annual production of anthracite in the State is almost twice that of bituminous coal. Approximately one hundred forty thousand men are employed and if these men and their families be considered, as well as the many other people of the region depending upon the industry, anthracite mining attains considerable significance. These people live in a number of cities and villages all based upon the presence of anthracite. Moreover, although anthracite does not enter to a great extent into manufacturing, attention should be called to the important silk mills and shirt factories of the anthracite region, which depend largely upon female labor from the miners' families, and, hence, indirectly, are dependent upon the presence of the anthracite deposits.

Close concentration both of land holding and mining characterizes the anthracite industry. Although the anthracite region, lying in east-central Pennsylvania, embraces about 3,300 square miles, less than 500 square miles of this total area are underlain by workable coal beds, and to this more restricted section the anthracite industry is confined. The coal occurs mainly in four irregular basins known as the Northern, the Eastern Middle, the Western Middle, and the Southern fields (Figure 4)[1]. These basins are the bottoms of downfolds or synclines in which the coal beds were protected from the erosion which stripped them from the surrounding country, removing all but about 6 per cent of the original deposits of the region. The beds mined vary in thickness from 50 feet down to 2 feet, becoming, in general, thicker from north to south. Unlike the situation in the bituminous coal fields where one bed is usually all that is mined in one locality, the mines of the anthracite region frequently obtain coal from a number of beds. Thus, as coal producers, the basins have an importance out of all proportion to their area.



TRADE REGIONS
1. Schuylkill 2. Lehigh 3. Wyoming
4. Sullivan County

Fig. 4. Producing fields and trade regions of the Anthracite District of Eastern Pennsylvania.

Organization of The Anthracite Industry

Mining in the anthracite region is chiefly in the hands of two groups. The "companies", so called because of their historic connection[2] with the railroad companies of the region, are ten in number, own their own lands, produce 70 to 80 per cent of the coal, and own something like 90 per cent of the reserves. In another group are 100 or more operators, the "independents", having for the most part no historic connection with the railroads, leasing the lands on which they operate on a royalty basis, and selling their product at higher prices in times of scarcity and lower prices in periods of abundance than do the "companies". All of the "companies" are large concerns while the "independents" include in their number a few large concerns and all of the small ones.

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[1] The Sullivan County or Western Northern Field produces a semi-anthracite. Since this coal is treated and marketed like anthracite, it is included with it in the graphs, but being small in amount is not discussed in the text.

[2] At one time the railroad interests produced approximately 75 per cent of the tonnage mined, and controlled 90 per cent of the unmined reserves. In 1908 the Supreme Court ordered the separation of some of the coal companies from the railroads.

Production and Preparation of Anthracite

In the anthracite region coal is produced from 3 sources — coal beds occurring in bed rock, culm banks, and river deposits. The bed-rock deposits are, of course, a natural occurrence, while the culm banks and river deposits are the waste products of an earlier period of mining.

Mining of Anthracite

The bed-rock deposits are naturally by far the most important (Figure 5). Where the coal occurs near the surface, stripping or surface working is possible; but, ordinarily, underground methods have to be resorted to, the difficulty and expense of these operations being proportional to the intensity of the local folding and fracturing of the rock layers. Shafts, slopes, and drifts are all used to reach the underground workings which, for the most part, follow a modified room and pillar system of mining. In general, mining is easier in the Northern and Eastern Middle fields as the rocks are less disturbed, but as a result of this easier mining much of the most available coal has already been removed and the production per man is now no higher than that of the other fields. Mechanization, making such strides in the bituminous fields, is limited in the anthracite region by the bent and fractured condition of the rocks. Uniformity of conditions is the exception, and only about 1½ per cent of the coal is machine mined as compared with 75 per cent for the bituminous mines of the State.

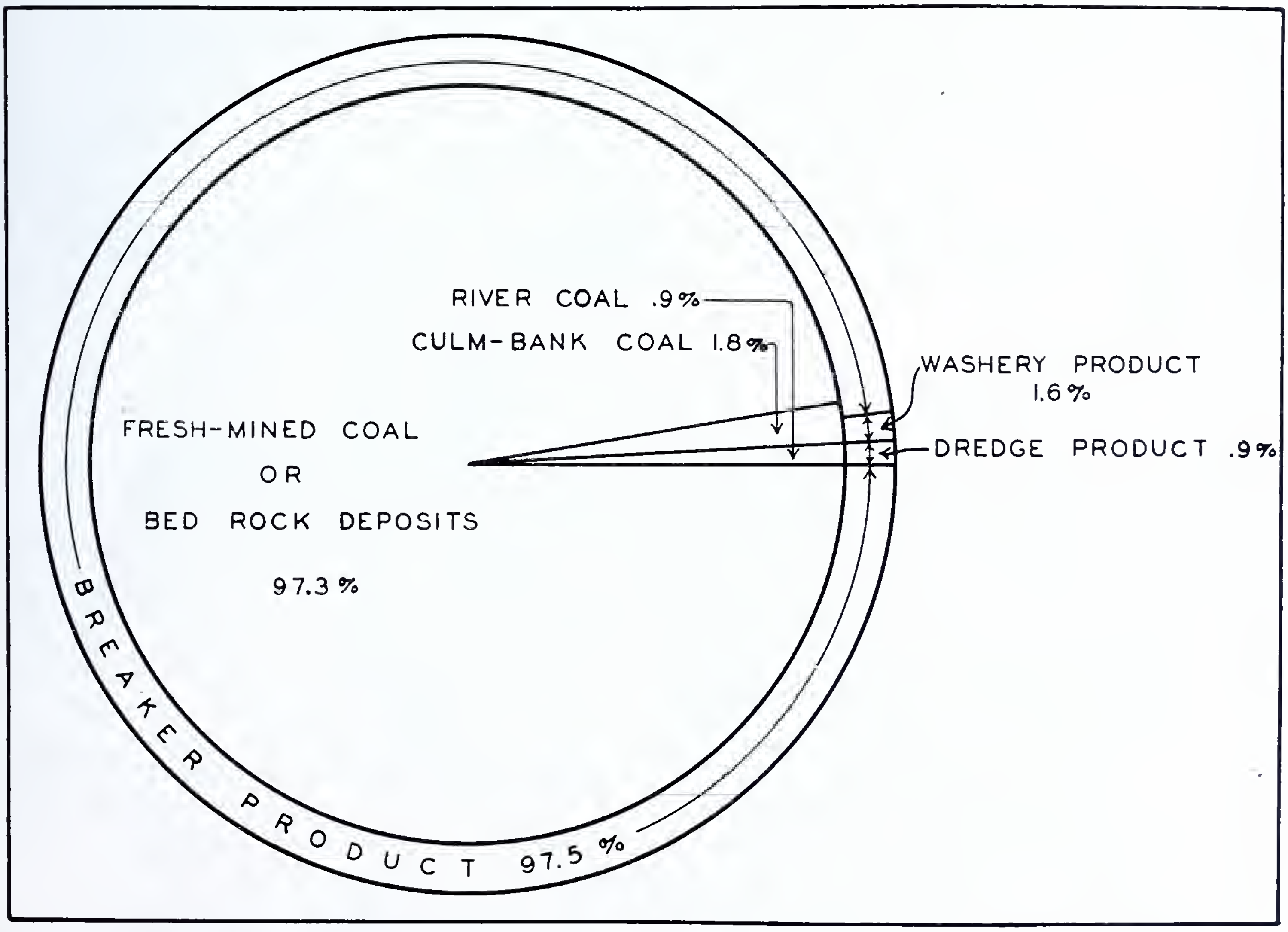

Fig. 5. Analysis (by weight) of production of anthracite in Pennsylvania as to source and method of production, 1930. (Data from Mineral Resources of the United States.)

Preparation of Mined Coal

It has frequently been said that anthracite mining is a manufacturing as well as an extractive industry. Whether or not the term "manufacturing" should be applied, it is certain that a great amount of processing of the raw product is necessary after it leaves the mine, even though it has already undergone a picking-over by the miner at the working face. As it comes from the mine the coal contains large quantities of slate and other impurities and is unfit for consumption. To prepare the product for market, it is treated in breakers, great structures of steel, concrete, and glass which are characteristic features of the landscape in the anthracite region.

It has been aptly pointed out that the breakers might better have been called "preparators" since crushing constitutes only one of the many steps of the preparation process. In the breakers, which are operated largely by electricity, the coal is crushed and the slate and refuse sorted out. Three methods of preparation are in use, known as the dry, the dry and wet combined, and the wet, but the last is now used for the preparation of over 90 per cent of the coal and its relative importance is increasing from year to year. Whatever the method of preparation, screening eventually results in the separating out of the various market sizes (Figure 6 and Table IV).

Here again the more favorable mining conditions in the Northern and Eastern Middle fields are in evidence, resulting in a greater percentage recovery of the large sizes from these than from the other fields.

Culm-bank Recovery

Culm banks are piles of fine coal with some slate and bone refuse which accumulated near the breakers during the early days of the industry when there was no market for what is now known as "chestnut" or for smaller sizes. As modern developments made possible the use of finer and finer sizes, not only were smaller sizes sorted out in the breakers as the coal was mined, but the culm piles were attacked as well, by the use of small screening and washing plants.

At present the older and richer culm piles have been largely worked over, but large modern washeries treat the more recent waste piles re-

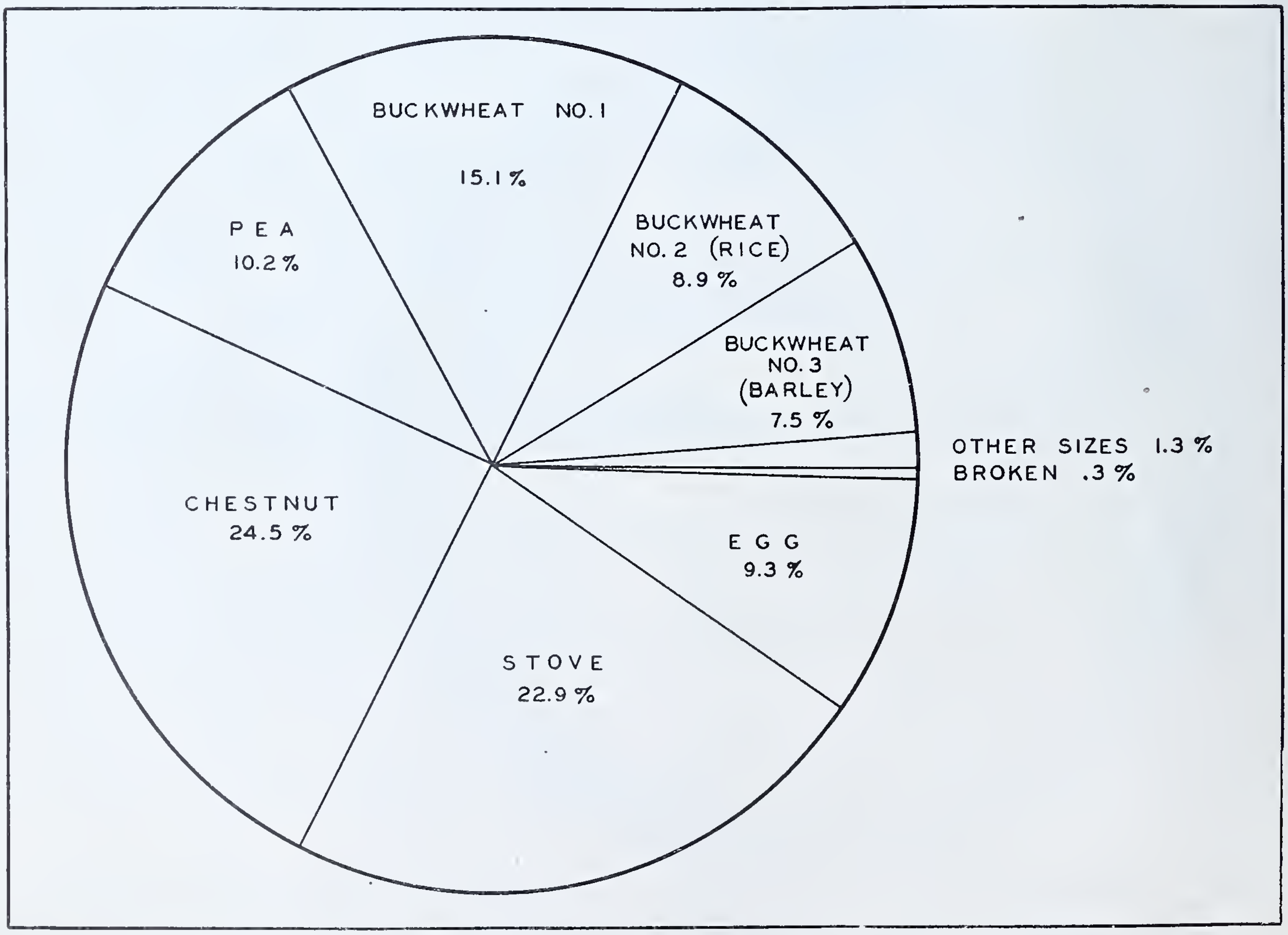

Fig. 6. Sizes of anthracite shipped, 1931. (Data from Mineral Resources of the United States.)

TABLE IV

THE STANDARD SIZES OF ANTHRACITE, THEIR USES, AND THEIR AVERAGE SELLING PRICES

(Adapted principally from Keystone Coal Buyer's Catalog for 1930 and from Mineral Resources of the United States.)

	Commercial Name	Average Diameter		Principal Uses	Average sales realization per short ton shipped from breakers, all regions, f. o. b. breakers, 1931
		Less than	Greater than		Dollars
"Domestic" sizes	Broken	4-3/8″	3-1/4″	Gas making, other manufacture, and steam raising	6.74
	Egg	3-1/4″	2-7/16″	Domestic furnaces and open grates	7.01
	Stove	2-7/16″	1-5/8″	Kitchen ranges, base burners (sometimes mixed with chestnut coal), small furnaces, open grates	7.37
	Chestnut or Nut	1-5/8″	13/16″	Kitchen ranges, small stoves, base burners (sometimes mixed with stove coal), and small open grates; also heating service water and homes	7.21
	Pea	13/16″	9/16″	Domestic furnaces with small openings in grate, kitchen ranges, and "banking" fires; also heating service water and homes	4.76
"Steam" sizes (though Buckwheat No. 1 finds considerable domestic use).	Buckwheat No. 1	9/16″	5/16″	Steam making, and self-feeding domestic furnaces; domestic stokers	2.79
	Buckwheat No. 2 or Rice	5/16″	3/16″	Steam making; domestic stokers; anthracite gas	1.52
	Buckwheat No. 3 or Barley	3/16″	3/32″	Steam making, and chemical and industrial processes	1.03
	Boiler	5/16″	3/32″	Same as the last two buckwheats	0.29
	Finer than Buckwheat No. 3			Briquets, producer-gas plants, powdered and burned either mixed with powdered bituminous coal or by itself.	Variable but less than for larger sizes except Boiler

sulting from the breaker operations of a few years ago and from the crude washing plants which treated the original culm piles. Many of these washeries are operated by the same companies which operate the bed-rock mines, and a certain amount of the culm-bank coal is today treated in the breakers instead of being put through the washeries (Figure 5). Altogether, however, culm-bank coal makes up only a small part of the anthracite produced in Pennsylvania (less than 2 per cent) and the product has a large proportion of the smaller and less valuable sizes. Moreover, gradual cleaning up of the culm piles and adverse market conditions have caused a sharp decline in the production of culm-bank coal within recent years, and, as less fine coal is being discarded at the present time than formerly, production from this source can never become very important.

Dredging

River coal includes the deposits of small sizes which have been washed with the waste water from the breakers and washeries, and deposited here and there along the river bottoms. Such coal, recovered by dredging, totalled a little over 570,000 gross tons in 1930, or about half as much as the culm-bank coal. Though obtained at various points along the Lehigh, Schuylkill, and Susquehanna rivers, the main operations are on the Susquehanna both on the North Branch and along the main stream below Sunbury.

The industry is handicapped by cold weather, almost stopping during the midwinter months when the demand for coal is greatest; and, since only the very smallest sizes are obtained, the value of the product is low, amounting to about $540,000 in 1930.

Dredging operations are carried on very largely by separate companies not connected with the great mining corporations, and the number of these dredging companies increases and decreases with rise and fall in the price of anthracite. Since little fine coal now reaches the streams, the dredging industry will become progressively less important in the future.

Some Problems Connected With Anthracite Mining

1. Surface Subsidence.

The question of surface subsidence due to caving of underground workings has long been of keen interest in the anthracite region. The first deeds for surface land overlying the anthracite reserved the right to mine the coal, and made no mention of surface protection. Deeds a little later contained the provision that one-fourth, one-third, or one-half of the coal was to be left properly distributed in pillars to support the surface. Although some deeds specifically stated that the remover of the coal was not to be held liable for damages to surface property, still others contained the provision that the coal company would repair any damage to sidewalks, buildings, or other surface structures. Surface subsidence is a commonplace occurrence in the anthracite region, and it has not infrequently resulted in damage to surface structures. The resulting litigation has frequently hinged upon the wording of the original deed, or upon whether or not a stipulated one-fourth or one-third of the coal had been left. Quite often the matter has been settled by the coal company paying some portion of the cost of repairing the damage at the surface.

Since many of the original leases contained the provision that the coal companies were not liable for damages resulting from surface subsidence, and since valuable coal deposits still remain beneath settled areas where such leases prevail, a number of people have become so interested in surface protection as to work for nullification of these original waiver clauses. It is unlikely that this will be accomplished. More practical adjustments have been the purchase by industrial plants of the coal underneath their land, thus preventing mining of the coal with consequent subsidence damage; and the recommendation that schools and other public buildings be low structures, planned to withstand the conditions as are the buildings within earthquake zones.

2. Waste Disposal and Stream Pollution.

A problem of the anthracite region as of many mining districts is the disposal of large quantities of silt and rock which are the waste products of the industry. When dumped into streams the stream water is polluted, fine coal is wasted, and deposits so clog the channels that floods are common, in some instances causing considerable damage.

In the Northern Field the broad valley supports a dense population, and it is highly desirable to keep the surface clear of waste. At the same time, valuable coal in the form of pillars is left to support the surface, since robbing the pillars would cause subsidence with damage to the surface structures. In a number of instances these two problems have been solved together by using the silt as mine filling. In a few months the silt solidifies enough to support the overlying rocks, and allow robbing of the solid coal pillars left for temporary support. Some rock and boiler ashes have been added to the silt thus used. The net results of the whole process are the obtaining of a larger coal recovery and a marked reduction of waste accumulations at the surface.

Another desirable result of the use of waste as mine filling is that it prevents pollution of the stream waters of the region. To this end, also, the anthracite operators appointed a committee of engineers to hold meetings with engineers representing the Sanitary Water Board and the Water and Power Resources Board of the State Government in an effort to find measures to reduce the discharge of silt from coal breakers to the streams draining the anthracite region. Operators who, through the use of sludge ponds or other methods, are saving most of the silt that would otherwise be carried off, are aiding in this matter of stream purification at the same time that they are accumulating a product which has or will have value.

Utilization and Marketing

Of the total usable anthracite produced, about 7 per cent (by weight) is used at the mines for power and heat. The coal thus used is mostly of the very small sizes which would be unmarketable, or, if sold, would command only a low price. It is, therefore, of much less importance than the 7 per cent would suggest. The remainder of the usable coal is either shipped or sold locally, and the coal disposed of in these ways constitutes the commercial or revenue-bearing part of the production.

Local sales (including a considerable amount of anthracite trucked from the mines) consume about 4 per cent of the usable coal produced. These sales are to the people of the communities within the anthracite region, and to the local industries and railroads. Although local sales consist of a larger proportion of the small or "steam" sizes than do shipments, it must be remembered that firing practices have reached a higher level in the anthracite-producing region than is the average condition throughout anthracite's market territory, so a considerable portion of the product sold locally probably is used for domestic purposes.

The remainder of the usable anthracite, amounting to 88.3 per cent of the total volume of production and to a somewhat larger percentage in terms of value, is that which is loaded at the mines for shipment. Of the anthracite loaded for shipment, about 30 per cent consists of steam sizes and the remainder of the so-called "domestic sizes" (See Table IV, page 9). Thus the marketing problem divides itself into the marketing of steam sizes and the marketing of domestic sizes.

Steam Sizes

The major object of anthracite mining and preparation is to produce domestic sizes. Steam sizes are incidental, or, in a sense, a by-product of the normal mining operation, although a portion of the steam sizes result from culm bank working and dredging. The marketing of steam sizes has long been a major problem since they must be marketed in competition with bituminous coal. The price obtained for the steam sizes is generally considerably less than the cost of production, the loss being carried by the domestic sizes; but the production of the small sizes cannot be eliminated, and once they are produced any price is better than none.

Steam sizes are used in various kinds of manufacturing, including the manufacture of gas; by utilities; by local railroads; for heating hotels, apartment houses, or office buildings; and in domestic stokers (Figures 6 and 7 and Table IV). The market area for steam sizes is extremely limited, being practically confined to New York, Philadelphia, and an area within about a 100-mile radius of the mines. Not only is there an actual loss on the steam sizes, but the limited character of the market is a limitation on total anthracite

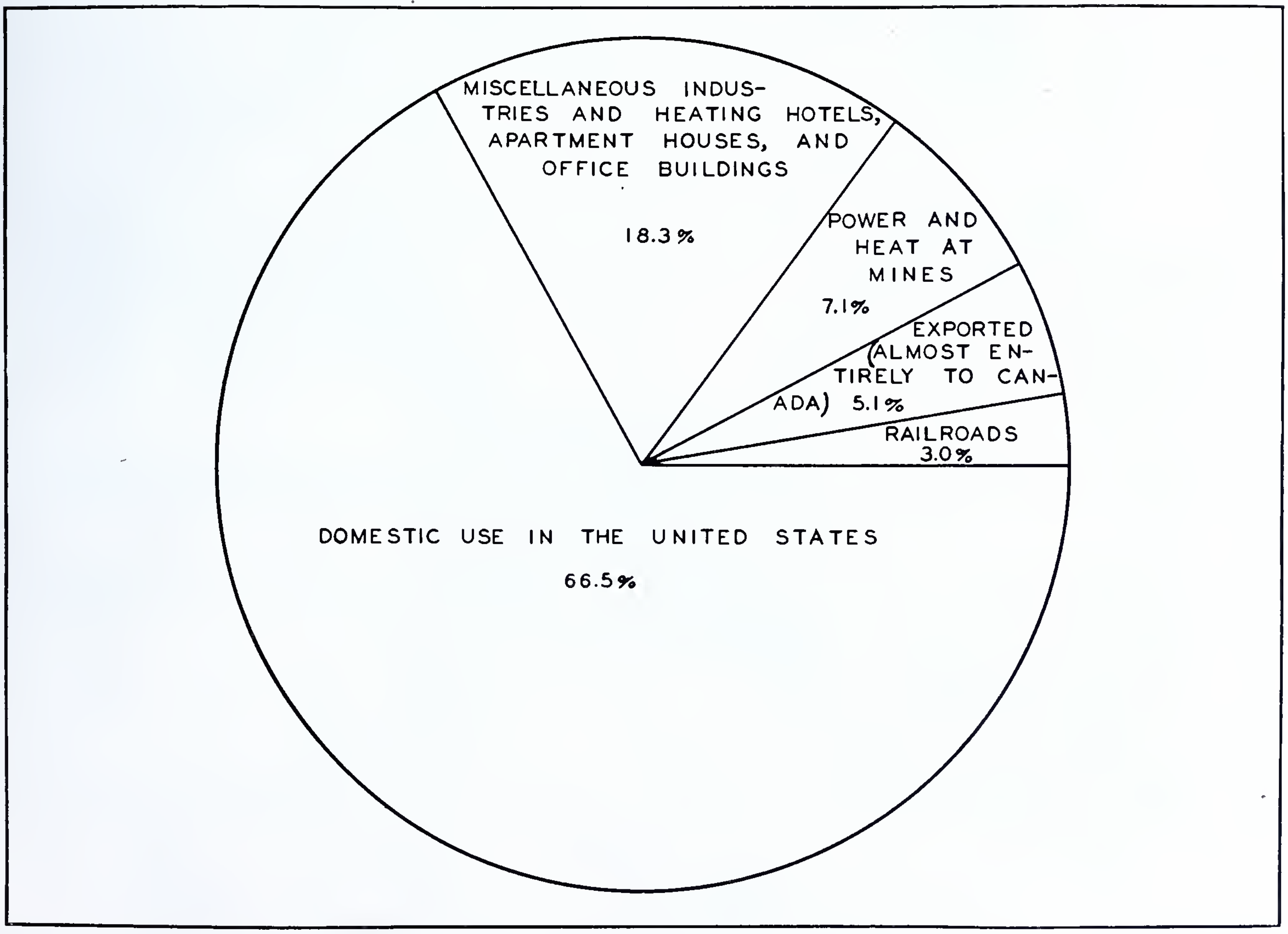

Fig. 7. Purposes for which the anthracite produced in Pennsylvania in 1929 was used. (Estimates, based on Mineral Resources of the United States and other sources.) The anthracite used for other than domestic purposes is predominantly of the finer or "steam" sizes. In this connection see Table 4, page 9.

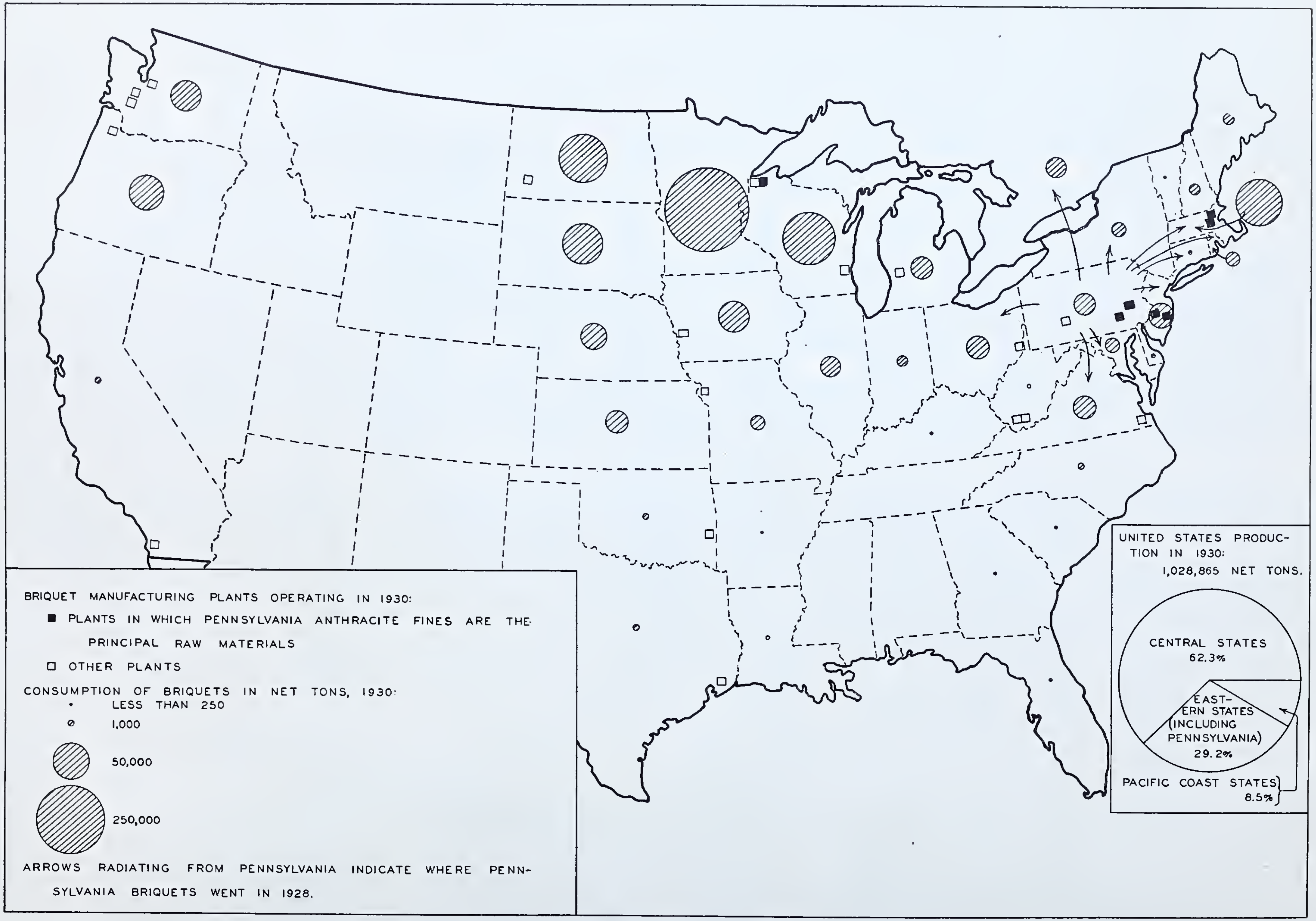
BRIQUET MANUFACTURING PLANTS OPERATING IN 1930:
■ PLANTS IN WHICH PENNSYLVANIA ANTHRACITE FINES ARE THE PRINCIPAL RAW MATERIALS
□ OTHER PLANTS
CONSUMPTION OF BRIQUETS IN NET TONS, 1930:
LESS THAN 250
1,000
50,000
250,000
ARROWS RADIATING FROM PENNSYLVANIA INDICATE WHERE PENNSYLVANIA BRIQUETS WENT IN 1928.
UNITED STATES PRODUCTION IN 1930:
1,028,865 NET TONS.
CENTRAL STATES
62.3%
EASTERN STATES (INCLUDING PENNSYLVANIA)
29.2%
PACIFIC COAST STATES
8.5%

Fig. 8. The domestic fuel briquet situation, 1930. (Data from Mineral Resources of the United States.)

output, since something must be done with these smaller sizes. Sometimes they are stored until the market will absorb them, but there have been cases of actual stoppage of production through inability to dispose of fine sizes produced. Research has shown that by use of proper equipment buckwheat and even some of the rice and barley can be used for domestic purposes. This downward extension of the minimum size limit of domestic anthracite, a recent development in the industry, should prove a most effective way of combating the lack of market for the steam sizes. Such developments seem amply to justify the demands of those who say that there is, at present, too much of a price differential between the buckwheats and the larger sizes of anthracite.

Sizes Finer than "Steam"

More and more, use is being made of sizes finer than "steam", which until recently were wasted. It is found that such material may be converted into briquets, may be burned in powdered form either by itself or in a mixture with bituminous coal, may be used in small producer-gas plants, or used in other ways. Where these fine sizes can be utilized it is desirable to do so, since it lessens the cost burden to be borne by domestic sizes, while at the same time disposing of a waste product.

The Fuel Briquet Industry.

When anthracite fines or bituminous coal slack are mixed with binding material and compressed into a solid lump, approximating a piece of stove coal in size, the product is known as a "fuel briquet." Briquetting gives artificially to fines or slack a physical state which makes possible their use as a domestic fuel in competition with stove sizes of anthracite and bituminous coal.

The country's domestic fuel briquet situation is presented graphically in Figure 8, in which it may be noted that three plants operated in Pennsylvania in 1930—one at Lykens in Dauphin County, one in North Manheim Township in Lancaster County, and one at Dunlo in Cambria County. To a minor extent, briquet manufacture furnishes a market for fine sizes of anthracite and bituminous coal, but this market is of questionable value to the industry since completed briquets compete with the raw fuels.

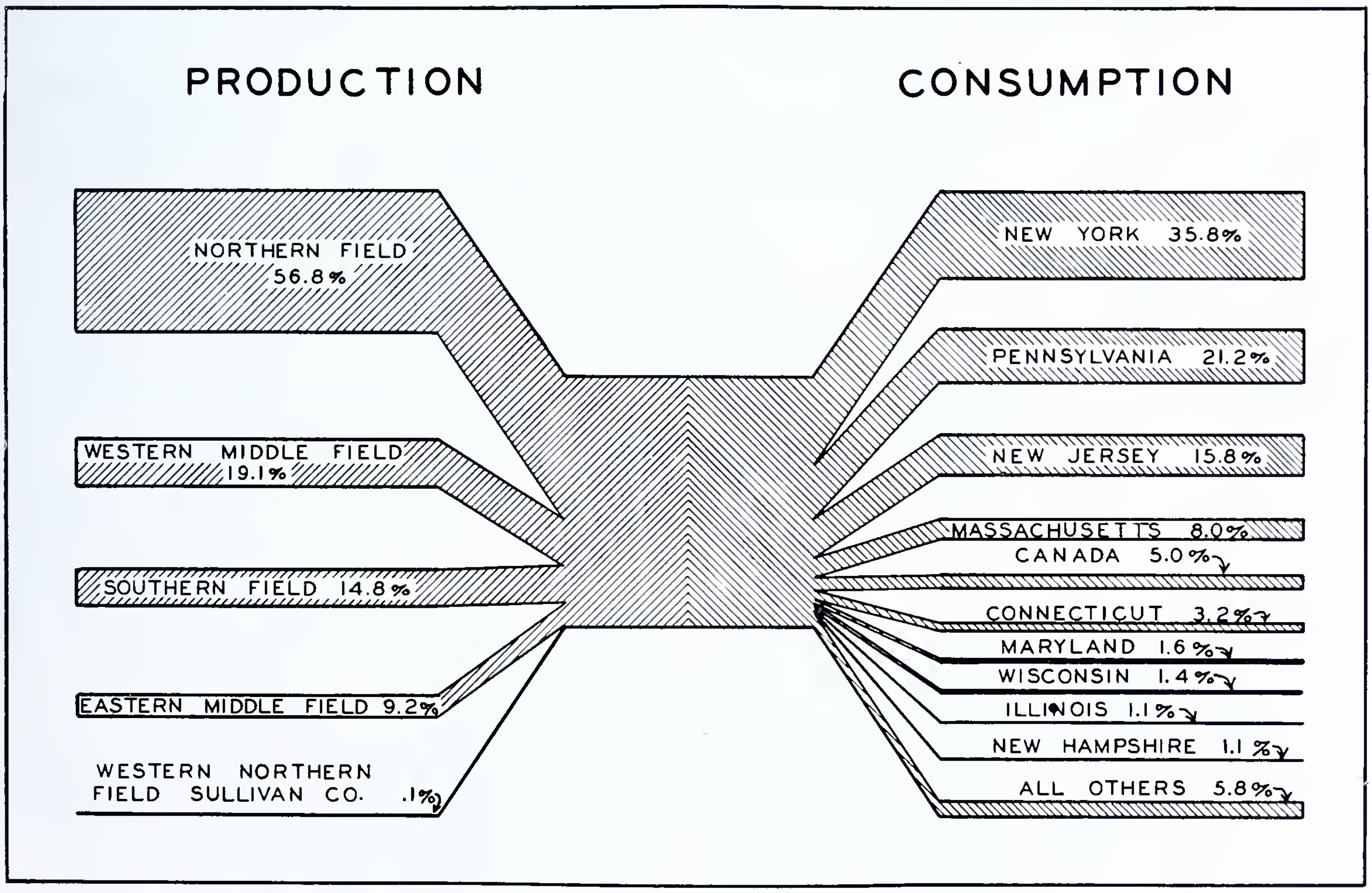

Fig. 9. The flow of anthracite from producing fields to areas of consumption for the coal year 1928-29. Numbers to left of center are percentages of total production; those to right are percentages of total consumption. (Production data from Mineral Resources of the United States, 1929; consumption data from Industrial Survey of the Wyoming Valley, Pennsylvania, Wilkes-Barre Wyoming Valley Chamber of Commerce, 1930, p. 63.)

The Domestic Market

Since such a large proportion of the anthracite shipped is used for domestic purposes, the disposal of domestic sizes is of particular interest and importance. Though nearly every state takes some domestic anthracite in a year of normal distribution, it finds its principal market in northeastern United States—in New York, Pennsylvania, New Jersey, and the New England states—and in Canada (Figure 9). A cold climate and a dense population not too far from the source of the anthracite form the basis for these markets, and there is little doubt that this will continue to be the principal market territory.

Effect of Recent Strikes

In view of the areal concentration of the anthracite deposits it is not surprising to find that labor is particularly well organized. As might be expected, disagreements have arisen between operators and unions from time to time, and there have been several serious strikes; while the limited supply, high prices, and sometimes low quality of anthracite on the market during these strikes precipitated the troubles that face the anthracite industry today. The strikes of 1922 and of the winter of 1925-26 seem to have speeded up the progress of troubles which were, even before the strikes, gradually invading the industry.

Prior to the strike of 1925-26 the industry was remarkably stable. The demand was nearly always good, and storage by dealers permitted a fairly steady year-round output except during strike periods, as in 1922, or during years of flush culm-bank recovery as in 1917 and 1918. In fact, the output did not increase in proportion to the population of the market area, the surplus market being taken care of by substitute fuels. The strike of 1922 and the resultant shortage of anthracite was of necessity met by substitution of other fuels. By 1924 the industry appeared to have recovered, but shortly thereafter the strike of 1925-26 occurred with further substitution of other fuels. Unfortunately for anthracite, during the period following the second strike increasing visible supplies of the several other energy resources initiated keen competition; and the anthracite industry has never been able fully to recapture the markets it temporarily relinquished, nor again to reach the stability of 1924. While the physical capacity of the mines has changed but little, the production of 1931 (production being, of course, very largely determined by the amount which can be sold) was 24 per cent less than that of 1924 (Figure 10).

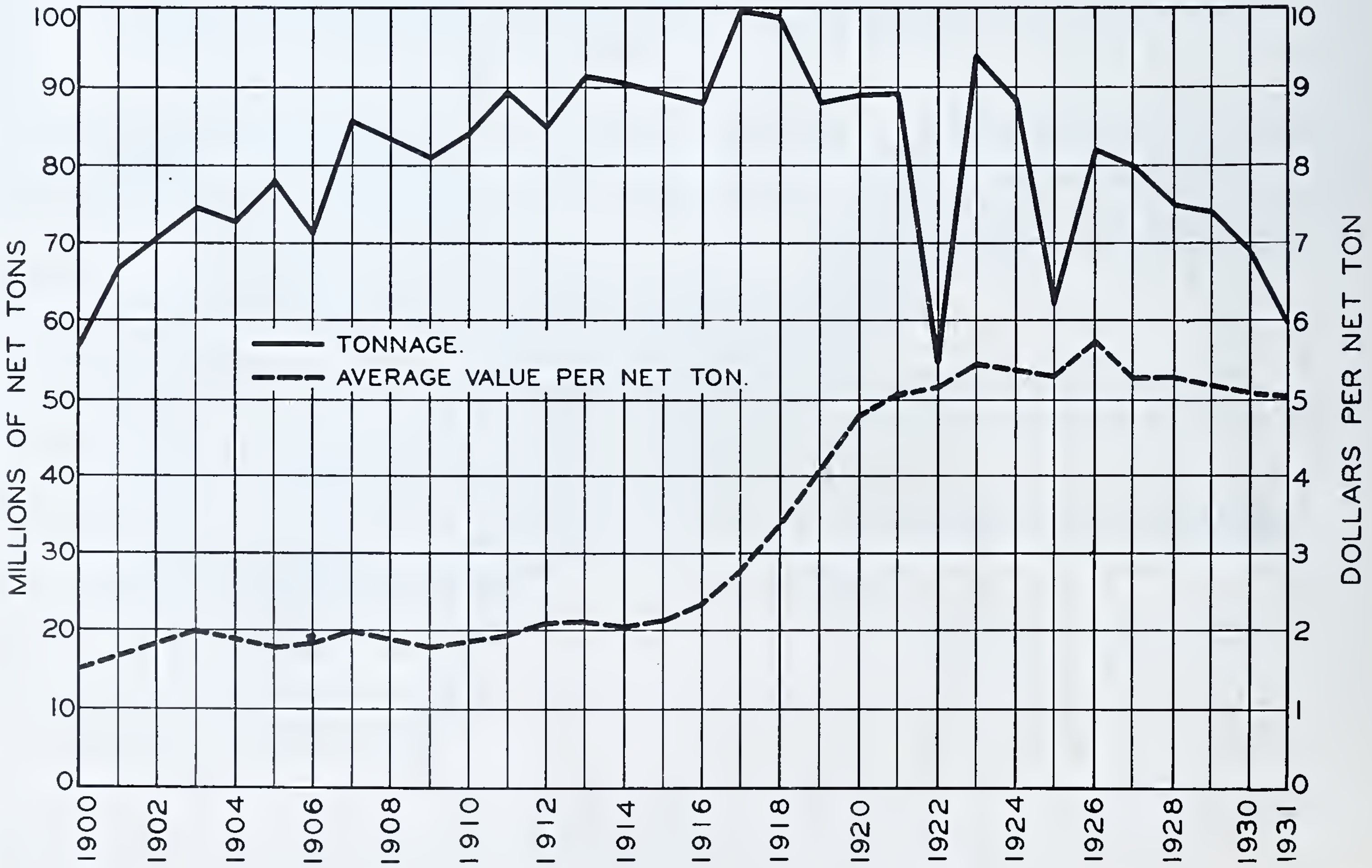

Fig. 10. Tonnage and average value per ton at breaker, washery, and dredge of anthracite produced since 1900. (Data from Mineral Resources of the United States.)

Competition with Other Fuels for Domestic Market

The principal invaders of the domestic fuel markets of anthracite are fuel oil, coke, natural gas, manufactured gas, fuel briquets, imported anthracite, anthracite and semi-anthracite produced in the United States outside of Pennsylvania, hydro-electric power, and bituminous coal.

Fuel Oil.

The use of fuel oil both for house heating and the heating of offices and public buildings has increased rapidly within recent years. For the United States as a whole the Bureau of Mines estimates that 5,021,000 barrels[3] of oil (including fuel oil, gas oil, furnace oils, and light distillates), were used in heating houses in 1924. This increased to 8,829,000 in 1925, and, in 1930, reached 25,359,000 barrels. The use of fuel oil for heating offices and public buildings (here competing chiefly with steam sizes of anthracite and with bituminous coal) increased from 12,100,000 barrels in 1925 to over 17,000,000 barrels in 1929, and maintained about the same figure for 1930. Of the 27,165,793 barrels of gas oil and fuel oil used in the United States in 1930 for domestic heating and for heating of offices and public buildings, approximately 40 per cent, equivalent to about 3,000,000 net tons of anthracite, was consumed in the Middle Atlantic and New England states, which include the principal anthracite markets. In part of this area bituminous coal is the chief fuel, and in these sections, of course, this fuel rather than anthracite is replaced by the oil. On the other hand, some anthracite is displaced by fuel oil in the North Central States.

It seems fair to conclude, therefore, that the fuel oil sold for domestic and commercial heating in 1930 represents a displacement of somewhere near 3,000,000 net tons of anthracite, an amount equal to about one-fifteenth of the total Pennsylvania anthracite used for similar purposes in 1930.

Coke.

The amount of by-product coke (produced in the United States) used for domestic purposes in the country in 1931 was 8,376,652 net tons as compared with 2,812,771 in 1924, a year of peace and steady demand. Beehive coke, produced within the country, supplied a much smaller part of the demand, the total used for domestic purposes in the United States being only 118,665 net tons in 1931. This was, however, 10½ per cent of all beehive coke produced in that year, while in 1924 only 1½ per cent of the beehive coke produced was used for domestic purposes.

Coke may be regarded as a very serious competitor of anthracite for the domestic fuel market, since in cleanliness and lack of smoke it is comparable to anthracite, and since it can be furnished at a lower cost than chestnut and larger sizes of anthracite.

It suffers from disadvantages, however, which should not be overlooked. Even the densest coke is so porous that it is difficult to charge enough into the average furnace so that it will hold fire for a satisfactory length of time, say over night. Since coke is so porous it requires much more storage space than anthracite. Moreover, it must be kept covered both in storage and in trucking, since, if it is exposed to water, coke will absorb a considerable amount. It is almost impossible to get rid of the water thus acquired, and the heating efficiency of the coke is lowered by its presence.

Coke is not a good fuel for mild days since to maintain combustion a strong fire is required. Important, too, is the fact that coke gives a hotter fuel bed than anthracite, thereby resulting in more clinkering and more danger of burning grate bars and fire pots.

Despite the several disadvantages outlined, the use of coke as a domestic fuel is undoubtedly growing. Moreover, most of the coke used for domestic heating is used in the northeastern quarter of the United States, and is thus in direct competition with anthracite. The rate of growth in this use of coke is very striking. In 1924 the amount used for domestic purposes in the United States was equal to about 4½ per cent of the anthracite so used; in 1931, about 20 per cent. Coke is likely to give particularly serious competition in markets some distance from the source of anthracite where freight adds considerably to the price of the latter fuel.

Imports of foreign coke, stimulated by demands of the strike of 1925-26, have continued higher than before the strike, being 103,563 tons in 1931 as compared with 82,833 tons in 1924. Some gas-house coke and some petroleum coke are also used in place of anthracite for domestic heating, but exact data covering these items are not available. (See also section on "Domestic Use of Coke" in Chapter V, Coal Processing.)

Gas.

Both natural and manufactured gas have been making inroads into the anthracite markets. Nat-

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[3] For purposes of comparison 1 net ton of anthracite may be considered as equivalent to approximately 4.2 bbl. of fuel oil.

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ural gas sold for domestic and commercial[4] use in the United States in 1931 totaled 380,897,000,000 cu. ft.,[5] 33 per cent greater than similar sales for 1924, and this gain has been a steady one. Of course, much of this natural gas is not in direct competition with anthracite, a considerable portion being used in regions where fuel oil or bituminous coal are the chief competitors. Moreover, in part of the anthracite market territory, for instance in New England, there is no competition at all from natural gas. It is true, however, that the use of natural gas for domestic and commercial purposes in the United States is increasing.

According to the United States Census 298,750,634,000 cu. ft. of manufactured gas were used for domestic purposes, including house heating, in the United States in 1929, and 47,743,942,000 cu. ft. for the kindred purpose of commercial heating. In addition, 160,560,921,000 cu. ft. of surplus coke-oven gas were distributed from by-product plants through city mains. Some of this manufactured gas was used outside of what could possibly be considered anthracite market territory, but a much larger proportion was consumed in northeastern United States and in the Central States, thus coming into competition with anthracite. In the field of house heating in particular it is claimed that the use of manufactured gas is increasing rapidly. The cost of house heating with gas is high, but the convenience is great enough in the opinions of many consumers to more than offset this high cost. It is in this house-heating field that gas competes seriously with anthracite, and promises to be a more serious competitor in the future.

Fuel Briquets.

The anthracite strike of 1925-26 with the resulting fuel shortage stimulated the production of fuel briquets in the United States (See page 13), and the increase in this industry, which produces a fuel competitive with anthracite, has never been overcome. In 1930 the production of fuel briquets amounted to 1,028,865 tons, an increase of 77 per cent over the 1924 figure, and a considerable part of this production was in the Eastern and North Central states where the product was in direct competition with anthracite. To the extent that the briquets manufactured in the United States are made from anthracite (about 36 per cent of the total raw material used in briquet manufacture is anthracite) this invasion of the market by briquets seems to be merely a case of a product made of anthracite in competition with the raw fuel. It should be noted, however, that the use of briquets represents practically an entire replacement of the equivalent amount of stove-size anthracite, since only the very fine sizes for which there would otherwise be no sale are used in briquet manufacture. Imports of briquets, coming chiefly from Germany, were practically non-existent in 1924, but rose to 123,593 tons in 1926, and have averaged about 70,000 tons since. Nearly all of the imports are marketed in New England.

Imported Anthracite.

Foreign anthracite, imported chiefly from Wales, brought relief to the coastal cities of eastern United States during the strike periods, and imports have since continued to play a more important role in the United States markets than they did before the strikes. Thus, in 1931, the anthracite imported (coming chiefly from the United Kingdom and Russia), though equal to only about 1 per cent of the Pennsylvania anthracite produced in that year, was over five times as great as the amount imported in 1924, suggesting small but consistent inroads on the domestic anthracite market. About 95 per cent of the anthracite imported enters the New England states.

Domestic Hard Coal Mined Outside of Pennsylvania.

Production of anthracite and semi-anthracite in the United States outside of Pennsylvania is confined to Arkansas, Colorado, New Mexico, and Virginia. Their products are generally known as "Arkansas anthracite", "Colorado anthracite", "New Mexico anthracite", or "Virginia anthracite" to differentiate them from "anthracite", the eastern Pennsylvania product. These coals are, in general, inferior to Pennsylvania anthracite.

In the first place, they are less uniform and standardized as to quality. Since they are softer than anthracite, there is usually more breakage in handling them; which means higher handling costs to the dealer, and, frequently, more fine sizes for the consumer, with resultant burning difficulties. They are usually freer-burning and harder to control than Pennsylvania anthracite. Having more volatile matter, they do not lend themselves as readily to thermostatic, stoker, or other methods of automatic control.

Virginia anthracite in the East and Arkansas anthracite in the Middle West supplied some of the deficiency of the strike years, and still compete with anthracite. The Arkansas product, for example, has been gaining markets in Missouri, Kansas, Nebraska, Iowa, South Dakota, and Minnesota, thus curtailing Pennsylvania anthracite markets in these areas. Colorado and New Mexico are too far away from the major anthracite markets for their hard coal to compete seriously with the Pennsylvania fuel. Though the production of anthracite and semi-anthracite outside of Pennsylvania has increased relative to the production of anthracite within the State within recent years, it still amounts to only about 1 per cent of the United States total, and, as pointed out, only a part of this 1 per cent really enters into active competition with anthracite.

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[4] "Domestic" as used in this book refers to cooking and house heating; "commercial" refers to the heating of office buildings, apartment houses, schools, hospitals, and similar buildings.

[5] For purposes of comparison, 1 net ton of anthracite can be considered as equivalent to approximately 28,800 cu. ft. of natural gas and to about two times that large a volume of average manufactured gas.

Hydro-electric Power.

Water power competes, to a certain extent, with anthracite coal through the medium of electricity. Electricity is not, as yet, much used for heating homes, though this may be a development of the not distant future. Its use for cooking, however, is increasing in popularity, and in this use electricity competes with anthracite. Though much of this electricity is generated by the burning of bituminous coal, some is hydro-electric power, and to this extent water power enters into competition with anthracite.

Bituminous Coal.

The fuel most widely used to replace anthracite during the winter of 1925-26 was bituminous coal. Calculations by the United States Bureau of Mines suggest that, during the period of the strike, retailers in the anthracite market territory sold approximately 17,000,000 tons more bituminous coal than normal, this coal going to replace both steam and domestic sizes of anthracite. The Interstate Commerce Commission established special all-rail rates on prepared sizes from the bituminous fields to the anthracite-using territory to help supply the temporary coal deficiency. Anti-smoke ordinances were relaxed. Producers of "smokeless" bituminous coals opened up demonstration stations in the anthracite market territory, and thousands of consumers learned to use these cheaper coals in stoves and furnaces designed for anthracite.

No exact figures are available as to the extent to which the bituminous coal industry has retained its hold upon the temporary markets which it gained in the anthracite territory in the strike year. Certainly, the substitution for anthracite of bituminous coal and coke, and manufactured gas made from bituminous coal, has played an important part in the market constriction now troubling the anthracite industry. In addition to the forms of competition mentioned, bituminous coal, like water power, competes with anthracite and gas for a portion of the domestic cooking market through the medium of electricity. (For further details of anthracite's competition with bituminous coal see "Regional Consideration of Anthracite Markets", p. 18).

Efforts to Meet Competition.

Naturally the producers in the anthracite region have not been quietly watching the invasion of their markets, but have, instead, been taking vigorous steps within the last few years to rehabilitate their industry. The Anthracite Institute, representing both the larger companies and the independent producers, has been leading in these activities.

The Anthracite Service. — One of the most important activities of the Institute is the Anthracite Service. From the offices which it maintains in thirty of the larger cities in the anthracite-consuming territory, engineers maintain direct contact with local coal dealers and anthracite consumers. The activities of these engineers include, in addition to service work, instruction of dealers and their employees in combustion engineering, the conducting of market surveys, and study of the anthracite needs of various industries.

The Anthracite Service cooperates with local coal dealers in advertising and in promoting sales in every way possible. As a part of this assistance to dealers, the Service publishes a monthly paper, "The Anthracite Salesman," which is forwarded to all anthracite dealers in the United States and Canada.

Public relations work is carried on from the district offices of the Anthracite Service. Motion pictures of anthracite origin, mining, preparation, and use are exhibited before clubs, schools, etc.; educational literature regarding the proper methods of using anthracite is published and widely distributed; news releases are issued to inform the public of developments in the heating field; and exhibits are displayed at conventions.

All of these activities of the "Anthracite Service", designed to serve the interests of the industry and the consumers, are carefully coordinated with the other activities of the Anthracite Institute.

Research. — Another important activity of the Institute is the subsidizing of research on the nature and use of anthracite. The research activities of the Institute may be subdivided into, (1) fundamental research, and, (2) research in the methods and equipment for using anthracite.

Research of a fundamental character is being carried on by the Institute in the School of Mineral Industries at the Pennsylvania State College, where laboratories have been equipped for the work and a regular staff is maintained. The work at State College involves studies of the exact character and behavior of anthracite, not only to improve its use as a fuel, but in order to develop new uses as well. The use of small-sized anthracite as a filtration agent is one subject which has been under investigation. Another line of investigation at State College has been the making of tests to determine the possibility of use of the shales which occur adjacent to the beds of anthracite. In these and other ways scientific research is being applied to the problems of the industry.

Research covering equipment and methods of burning anthracite is being carried on by the Institute at Primos, Pennsylvania, near Philadelphia, where a fully-equipped laboratory is maintained. Here equipment for burning and regulating is evaluated, and automatic-stoking devices and ash-removal appliances are tested and experimented with.

Consumers require widely varying types of heating, and research is carried on at Primos to the ends of satisfying these different demands, of furnishing cost figures for those primarily interested in the cost of heating their homes, and of developing safe and reliable automatic heating systems.

The Anthracite Bureau of Information.—An agency of the Institute, the Anthracite Bureau of Information, compiles and publishes trade statistics for members of the industry, keeps its members informed of important developments affecting the industry, and supplies literature and moving pictures to various organizations. A credit bureau was established as an additional service in 1929.

Inspection Service. — Rigid standards of size and purity of product have been adopted by the Institute, and an inspection service is maintained of the breaker screens used and of the anthracite produced by the Institute's members. The results of these inspection tests are embodied in reports furnished to the companies which are members of the Institute.

Other Activities of the Anthracite Operators.—In addition to the various collective activities mentioned in the battle to rehabilitate anthracite, attention should be called to the extensive modernization programs that have been undertaken by many of the larger producing companies. It is generally admitted that many antiquated methods have survived in the anthracite industry. The efforts now under way consist, for the most part, of increasing and modernizing preparation facilities, but sales and service policies, too, have been receiving attention.

Regional Consideration of Anthracite Markets

The principal anthracite consuming territory may be separated on a regional basis as follows: the New England market, the Middle Atlantic market, markets west of Pennsylvania, and the export market.

The New England Market.

According to the United States Bureau of Mines, about 13½ per cent of the anthracite loaded for shipment in 1931 went to New England, a market not very far distant from the anthracite region. New England would appear to be ideal anthracite market territory, with its long, cold winters, a large urban population, and proximity to the anthracite fields. The condition and possibilities of the New England market are therefore of special interest in a discussion of anthracite.

New England is supplied with coal partly by coastwise shipments from the principal coal ports farther south, partly by all-rail shipments across the Hudson, and partly by imports from outside the United States. About 70 per cent of the total domestic (produced in United States) coal received in 1931 was bituminous; the other 30 per cent, anthracite. About 27½ per cent of the anthracite came by tidewater and about 69 per cent of the bituminous coal. It is not surprising to find that more than twice as much bituminous coal is received as anthracite, since bituminous coal is the dominant industrial fuel and New England is a very important industrial section. For a long time, however, anthracite enjoyed supremacy in the domestic and commercial fields, and it is for such purposes that most of the 7,080,000 net tons received from Pennsylvania in 1931 were used. According to the 1929 Census of Manufactures, less than 10 per cent of the anthracite received in New England is used in manufacturing.

In spite of anthracite's suitability for domestic use and commercial heating, New England receipts of anthracite from Pennsylvania have shown a decline within recent years (Figure 11).

Why has anthracite consumption in New England declined? What has taken its place? Available records indicate that the consumption of fuel oil for domestic and commercial uses in New England has been increasing rapidly within the last four or five years, amounting in 1930 to about 3,185,000 barrels, or the equivalent of perhaps 10 per cent of the Pennsylvania anthracite entering New England in that year.

Importation of anthracite from outside the United States increased 470 per cent from 1924 to 1930, and in 1931 was equivalent to 9 per cent of the anthracite coming into New England from Pennsylvania.

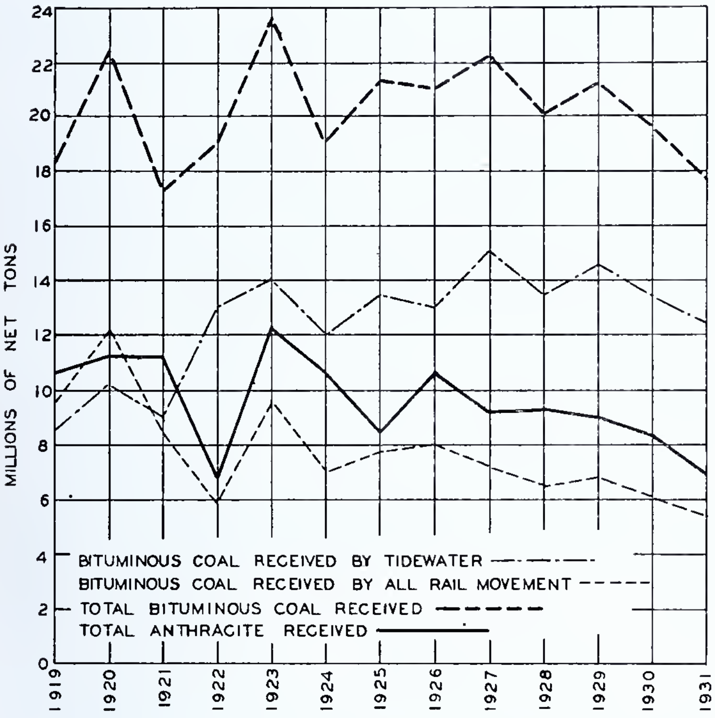

Fig. 11. Receipts of bituminous coal and anthracite in New England, 1919-1931. Curves refer only to coal or anthracite produced in the United States. (Data from Mineral Resources of the United States.)

The use of coke for domestic purposes in New England has gained rapidly since 1924, and the total amount thus used in 1929 appears to have been equivalent to about 7 per cent of the Pennsylvania anthracite entering New England.

No natural gas is used in New England, but manufactured gas (including surplus coke-oven gas) used for domestic and commercial heating in 1929 amounted to about 45,000,000,000 cu. ft., the equivalent in B. t. u.'s of between 700,000 and 1,000,000 net tons of anthracite. Of course, manufactured gas has been in use in New England for a long time, so only a small part of the total manufactured gas used represents recent displacement of anthracite. Nevertheless, domestic use of manufactured gas, particularly for house heating, is said to be increasing rapidly.

There is another substitute which seems to have played an important role in the restriction of anthracite's markets in New England—bituminous coal. In the pre-Depression period as receipts of anthracite in New England decreased receipts of bituminous coal increased (Figure 11). Naturally, since bituminous coal is predominantly an industrial fuel, not all of the bituminous increase has meant replacement of anthracite markets. Moreover, part of the increase in bituminous coal has gone into the manufacture of coke and manufactured gas, and so is already accounted for in the mention of these topics above. In spite of these mitigating facts, however, the increase in bituminous coal receipts is very striking.

Imports of bituminous coal are negligible, so it is apparently domestic bituminous coal which is causing the trouble. Domestic bituminous coal enters New England by tidewater from Atlantic ports and by all-rail shipment across the Hudson. The all-rail shipments, most of which originate in Pennsylvania, have been declining within recent years; but, until 1929, there was a fairly steady increase in tidewater receipts (Figure 11). In 1931 about 91 per cent of this tidewater coal reaching New England was shipped from Hampton Roads, originating in southern West Virginia and southwestern Virginia, and the percentage of New England's tidewater bituminous coal coming from this source has been increasing. It seems, therefore, that coincident with the decline of anthracite receipts in New England there has been a marked increase in bituminous coal received from the southern West Virginia area. The ability of this coal to compete with anthracite is better understood when it is remembered that that area is the home of famous low-volatile coals which have, if anything, a slightly higher heat value than anthracite, and burn more readily and without much smoke. It thus seems that the southern low-volatile coals, exported chiefly from Hampton Roads, are displacing both Pennsylvania anthracite and Pennsylvania bituminous coal in the New England market.

That the southern coals are able to compete so successfully with the nearer Pennsylvania products is probably due to lower mining costs in the southern fields, the possession by those fields of really excellent low-volatile coal, and cheaper ton-mile delivery charges from the southern fields. Water shipment is proverbially cheap, and the coal from southern fields is carried to Hampton Roads by railroads whose special business is the carrying of coal, and which, therefore, effect many economies.

The Middle Atlantic States Market.

The Middle Atlantic States[6] are the home of anthracite, and here about three-fourths of the total anthracite produced is consumed. According to the United States Census, about 7,000,000 net tons of anthracite were used in manufacturing in the Middle Atlantic States in 1929; nearly all of the remainder was used for domestic purposes and for commercial heating.

Anthracite faces competition from a number of minor fuels in the Middle Atlantic States market. Probably because of the presence of refineries in the Middle Atlantic States, fuel oil is of greater importance than in New England. The amount used for domestic and commercial purposes in these states in 1931 was 9,333,550 barrels, equivalent to about 2,200,000 tons of anthracite, and the total appears to be increasing. The use of fuel oil is greatest in the eastern part of this group of states, in eastern New York, New Jersey, eastern Pennsylvania, and Maryland.

Natural gas was formerly used only in the states of New York and Pennsylvania and chiefly in the western parts of these. Use of natural gas for domestic and commercial purposes in these two states amounted to 63,822,000,000 cu. ft. in 1931, equivalent to about 2,200,000 net tons of anthracite. Now natural gas is available at Washington, D. C., and it is likely that there will be a considerable expansion in its use in the Middle Atlantic States. Manufactured gas (including coke-oven gas) used for the same purposes in the Middle Atlantic States (in 1929) amounted to about 190,000,000,000 cu. ft., or the equivalent of approximately 3,000,000 net tons of anthracite. The use of gas for domestic purposes and for commercial heating is said to be increasing, though separate data to show the increase in the Middle Atlantic States are not available. Coke used in the Middle Atlantic States for domestic and commercial purposes in 1930 totalled 1,738,463 net tons. The steady increase in the use of coke for these purposes has been a significant feature of the fuel market in recent years.

In spite of the inroads of the several substitutes mentioned, anthracite and bituminous coal still dominate the fuel market of the Middle Atlantic States. Anthracite is the outstanding fuel for domestic and commercial heating, and is even used to a considerable extent in manufacturing, particularly in the anthracite counties. Outside of the anthracite counties, in industrial southeastern Pennsylvania, New Jersey, and eastern New York, bituminous coal dominates the industrial market although fuel oil and manufactured gas play some part. Farther west, in western Pennsylvania and western New York, bituminous coal is of much greater relative importance, though even there much anthracite is used for domestic purposes.

Markets West of Pennsylvania.

Anthracite moves west from Pennsylvania both by all-rail shipments and by rail-and-lake shipments.

The water movement consists of shipments by rail to Buffalo and Erie where the anthracite is loaded into lake steamers for transportation to upper Lake ports from which there is frequently further distribution by rail. Such lake-cargo anthracite shipments amounted to 761,000 net tons in 1931. The lake-cargo movement of anthracite has been steadily (Figure 12) declining, as have all-rail shipments west as well.

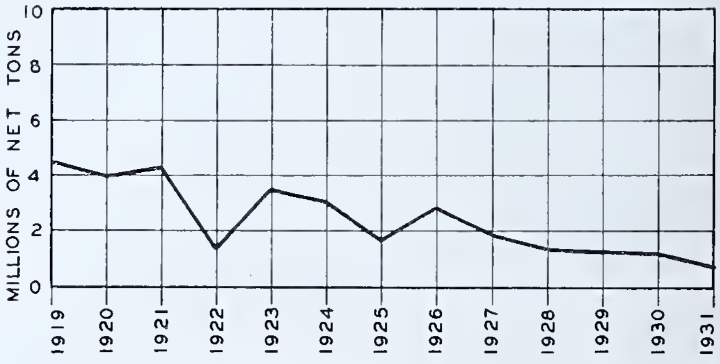

Fig. 12. Anthracite cargo coal loaded into vessels at Lake Erie ports. (Data from Mineral Resources of the United States.)

Decline of the western markets for anthracite was initiated during the World War when the Fuel Administration shut out anthracite from the West. The public tried other fuels, in many cases never returning to anthracite. Both fuel oil and gas have encroached upon domestic anthracite markets in the Middle West, as well as in the markets of the Plains states farther to the west. Fuel oil consumption is particularly high in Illinois, doubtless because of the presence of refineries there. Natural gas consumption for domestic purposes and commercial heating is particularly large in Ohio, but is becoming more important in other Middle West states, with the building of pipe lines from Texas and Oklahoma. Manufactured gas used for domestic and commercial heating in the Middle West amounted (in 1929) to about 100,000,000,000 cu. ft. or the equivalent of about 1,800,000 net tons of anthracite. This manufactured gas consumption is particularly small in Ohio where natural gas is available, and relatively large in Illinois and Michigan. Toward the southwest, natural gas becomes increasingly important. Moreover, Arkansas anthracite (really semi-anthracite), pressed by growing competition of oil and gas in the vicinity of its production, has been for some years expanding its market to the northward; and the shrinking demand for Pennsylvania anthracite in Missouri, Kansas, Nebraska, Iowa, South Dakota, and Minnesota is in part a reflection of this spread of Arkansas anthracite.

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[6] New York, New Jersey, Pennsylvania, Maryland, Delaware, and District of Columbia.

As in the other market areas discussed, coke is becoming increasingly important as a domestic fuel in the Middle West. Four million tons, more than half of the total coke used for domestic fuel, was marketed in the Middle West in 1929, thus curtailing anthracite consumption there.

Lake-cargo anthracite shipments, as well as all-rail anthracite shipments, to the Middle West meet increasing competition from southern Illinois and Indiana coals, and, even more, coals from southern West Virginia and adjacent areas. Both low and high-volatile coals are shipped northward and northwestward from the West Virginia-Virginia-Southeastern Kentucky area, the low-volatile coals, because of qualities similar to anthracite, being particularly serious competitors. Low production costs in the southern fields and low transportation charges for coal moving north from these fields accentuate the seriousness of this competition.

Export Trade in Anthracite.

Almost the only exports of anthracite are to Canada. Such deliveries are mostly to peninsular Ontario and the St. Lawrence Valley, and all but a small proportion of the anthracite reaches its destination by all-rail movement. This section of Canada has no coal of its own, and must either import bituminous coal and anthracite from the United States or Europe, or obtain coal by a long haul from Nova Scotia or Alberta.

Canada's coal can hardly furnish much competition for anthracite since the distance it must be hauled is too great, and, even more, since much of it is of too low a rank. Low-volatile bituminous coals from the West Virginia-Virginia-Southeastern Kentucky area have encroached somewhat upon anthracite's markets in Canada, but the haul is a long one, so it is unlikely that these coals can entirely replace anthracite. Severe competition, however, is arising from another source, Great Britain. Great Britain's part of the total Canadian anthracite imports rose from 14 per cent in 1928 to 27.6 per cent in 1931. Fostered by favorable tariff arrangements, this proportion increased to about 43 per cent in 1932 according to advance data. In addition to the Great Britain anthracite (which, by the way, is from Wales) some anthracite from Russia and some from Germany is on the Canadian market. It is the Great Britain product, however, which is the most serious menace to Pennsylvania in the Canadian anthracite market. In the main this is caused by high freight rates from the United States and the Canadian tariff structure.

Efforts of Industry to Meet Market Needs

The anthracite industry is making great efforts to meet the market needs. A number of these were discussed in connection with anthracite's competitive position. They include better preparation with inspection of product, cooperation with retailers and consumers, and development of stoves and heating systems especially adapted for the use of anthracite. Retailing of part of the anthracite in bags of 50 lbs. or other convenient weight is now planned to reach small-scale consumers. A reduction in the number of prepared sizes and adoption of one price for all the stove sizes would further simplify the problem for the consumer.

Future Markets

Northeastern United States and adjacent sections of Canada will doubtless continue to be the principal market area for anthracite. To the west the anthracite industry faces a long freight haul to markets which are much nearer bituminous coal deposits as well as the sources of other competing fuels; to the south higher temperatures, lower standards of living, and competition with bituminous coal prevent any considerable extension of markets. The need of the anthracite industry, therefore, seems to consist of a more thorough development of its present market territory with an extension of the use of anthracite within that area. Such steps are, of course, already being taken by the operators of the anthracite district.

Freight Rates

There is a very general impression that freight rates are too high in the anthracite region, a matter which, if true, is of concern both to the consumer and to the anthracite industry. High freight charges mean a high selling price, and not only does the consumer have to pay a high price for his coal, but the industry, through the necessarily high price of its product, yields to substitute fuels. On the other side of the case, it has been argued that the high value of the anthracite traffic, the separate shipping of many different anthracite sizes, and the lack of return traffic justify the present rate structure, that while the rates are high they are not too high when all factors in the situation are considered.

Taxation of The Anthracite Industry

There is little doubt that the anthracite industry bears a heavy tax burden, a matter of interest to the consumer since it operates to keep up the retail price of the fuel.

From 1921 to 1931 the State collected a special tonnage tax on anthracite, amounting to 1½ per cent of the value of the coal as prepared for market. In a minor way this tax encouraged the inroads of substitute fuels upon anthracite markets, since consumers in New England and elsewhere resented having to pay a special state tax. Fortunately, in 1929, the State Tonnage Tax was repealed by a measure which provided for the abolishment of one-third of the tax each year, the last third in 1931.

It has been charged that while most of the producers are overtaxed, insufficient consideration is given to differences in natural advantages possessed by the various mines. If, as mentioned on an earlier page, the high-cost producers set prices for the anthracite industry, then taxes should, to some extent, be readjusted to fall chiefly on the low-cost producer. A differential tax on royalties and on excess profits which come from the possession of coal of superior quality was suggested by the United States Coal Commission as a means of distributing the burden more fairly than it is distributed at present[7]. The question arises, however, as to whether such a procedure would not unduly encourage high-cost producers, who might better not be producing, at the expense of the low-cost producers.

Some companies own large reserves and upon these the present system of taxing coal in the ground imposes a heavy load. This matter will be discussed more fully in the last chapter of this book.

Major Problems of The Anthracite Industry

The principal difficulties which face the anthracite industry today can be summarized as follows:

1. Competition from other fuels.
2. High production costs, especially labor.
3. A heavy tax burden.
4. High costs of distribution, particularly freight, although retailing charges are also high.
5. Limited market for smaller sizes. (Note, however, that this market is improving.)
6. The existence of too many commercial sizes of anthracite with consequent high costs of preparation, transportation, and delivery to consumer.
7. Unfavorable attitude of unions toward plans to increase efficiency, including the introduction of labor-saving equipment.
8. Growing exhaustion of more cheaply mined deposits.
9. Increasing depth with attending gas, roof, and other troubles.
10. Increasing water.
11. Excess capacity entailing heavy carrying charges.
12. Too high royalties on some leases in view of present conditions.

Corrective measures advanced, some in practice and some merely suggested, include the following:

No more stoppage of production. (1)[8]

Advertising and service. These are the principal methods by which the industry is attempting to meet competition at the present time. (1)

Better cooperation between management and labor in increasing mining efficiency and lowering costs. (2, 7)

A detailed study of the tax problem from the point of view of present and probable future conditions of the industry. (3)

Further study of the freight rate structure of the anthracite railroads. It should be possible to determine whether the rates are actually too high, and, if they are, further demands for adjustment should be made. (4)

Better control of retailing to avoid excessive charges, improper representation of the product, etc. (4)

Utilization of the extremely fine sizes within the anthracite region for making briquets or for generation of electricity. (5)

Improvement of methods for the use of "steam" sizes for domestic heating, for heating apartment houses, hotels, and office buildings. Advances in the popularity of these smaller sizes will make it possible for them to bear more of the price burden which now weighs so heavily upon the larger sizes. Work along this line is being carried on under the direction of the anthracite operators. (5)

Reduction of number of sizes to 4 thus effecting a saving in costs which will make possible a lower price to the consumer. (6)

Development of equipment which will make it possible to burn anthracite more efficiently and more economically. (1, 5)

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[7] Devine, Edward T., Coal, Bloomington, Ill., 1925, pp. 351-353.

[8] The numbers following each corrective measure suggested refer to the difficulties in the preceding list which each suggestion most specifically meets.

Reduction of excess capacity by shutting down some mines, and concentrating production and preparation in the hands of those producers best equipped for efficient operation—principally with the end of avoiding the high cost of part-time mining. (2, 11)

Revision downward of some of the royalties which are too high for present conditions of the industry. (12)

Reduction of costs by all possible methods to the end that the price of anthracite to the consumer be put more nearly on a parity with the prices of competing fuels. (1)

Future of The Anthracite Industry

What is the probable future of the anthracite region? How long can coal mining, its principal industry, continue? One of the specialists of the United States Coal Commission, the organization which investigated the coal industry in 1922 and 1923, wrote on this question:[9]

"The largest reserves are in the fields presenting the most difficult mining conditions, the heaviest loss in mining, and the largest proportion of the less important steam sizes. . . .

"At their present rate of exhaustion the Northern and Eastern Middle Fields will be the first to show decreasing production. If the demand for anthracite persists, their waning production must then be made up by increased tonnages from the Western Middle and Southern Fields. The demand will probably still be for domestic sizes . . . in these latter fields production of a ton of these sizes involves a much larger inroad on the coal reserves [than production of a ton of domestic sizes in the Northern and Eastern Middle fields]. The relative proportion of this tonnage [domestic sizes] made up by each of these fields will therefore have a great effect upon their respective lives, as will the possible extent of the total demand through years to come.

"Sizes now used for steam only may then be used for domestic purposes. The constantly increasing cost of production may seriously limit the demand by bringing into economic competition other fuels. Again, the demand may reach unexpected proportions as necessity arises for smoke abatement in congested urban districts. All of which goes to show that any attempt to fix a definite life to any specific field, or to the region as a whole, is extremely difficult. Furthermore, the results attained cannot be very reliable, no matter how carefully the estimate is made.

"With so many uncertain factors involved, not the least of which is the precise amount of coal remaining in the ground, it is impossible to give exact figures as to the future life of the anthracite mines. Most estimates place the life at the present rate of production at somewhere between 60 and 120 years; say, very roughly, 100 years. [See Figures 13 and 14]. The Eastern Middle and Northern Fields, however, will be practically exhausted long before that period of years.

"In any case there will be some collieries in each field producing coal in small amounts long after these periods, but it appears that the expiration of 80 years will begin to see the present production rapidly fall."

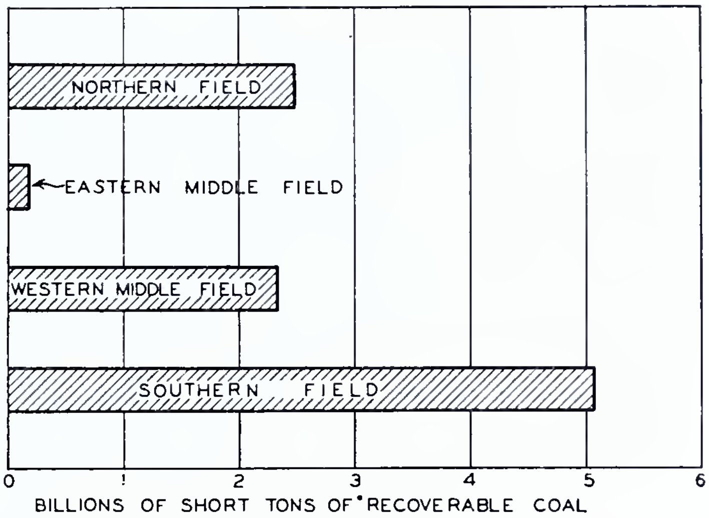

Fig. 13. Anthracite reserves. (Based on estimates in the Report of the United States Coal Commission, Part II, 1925, p. 1031.)

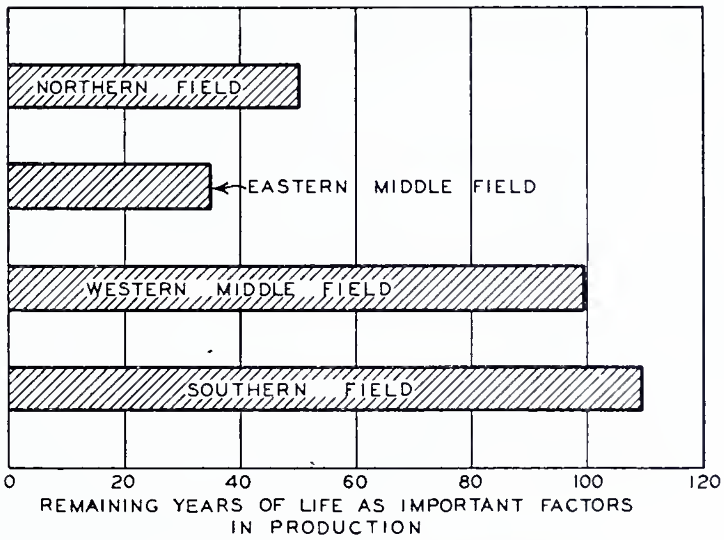

Fig. 14. Probable lives of anthracite fields. (Based on estimates in the Report of the United States Coal Commission, Part II, 1925, p. 1031.)

Although written several years ago, the above still holds true in most essentials. The increase in the use of smaller sizes which the intervening years have witnessed may extend the life of the anthracite industry somewhat. During the same period there has been a constriction of the anthracite markets, which tendency, if continued, may greatly increase the life of the industry. It is to be hoped, however, that market conditions will again improve and that the anthracite industry may remain vigorous and prosperous for the seventy-five to one hundred years required to use up the bulk of the known reserves under such conditions. Efficient use of resources is more in line with modern conservational policies than extension of the life of deposits at the expense of economy in production and marketing.

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[9] Walter, Raymond A., in "What the Coal Commission Found" by the Staff of the United States Coal Commission, 1925, pp. 343-344.

What will be the fate of the anthracite region after its coal has all been mined? At the beginning of the present century one student of the industry wrote:[10]

> "In the counties of Lackawanna, Luzerne, Schuylkill, Carbon, Northumberland, Dauphin, Columbia and Sullivan, coal is king. Without it, the flourishing towns and villages now teeming with life, containing many happy homes and thriving commercial enterprises, would be deserted; and the railroads which thread their way over these rich beds of anthracite and depend upon their contents for the major portion of their business would become little better than valueless. . . . When the coal beds shall have been exhausted, the greater part of the 1,700 square miles of territory occupied by them will be a 'howling wilderness' ".

Such a pessimistic view of the future of the anthracite region would certainly not be warranted in the light of recent developments. Attention may be called to the growing percentage of freight other than anthracite carried by the railroads of the anthracite region; of their development of terminal facilities making possible a growing trunk-line business; and of the "New Industries Departments" by which some of the railroad companies are seeking to attract new enterprises. A number of manufacturing industries, too, are already established, and, with the abandonment of coal mining, much desirable space and additional housing facilities will be available for others. With a good location and excellent transportation facilities it seems probable that greater manufacturing development will keep pace with the decline of coal mining.

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[10] Roberts, Peter, "Anthracite Coal Industry", New York, 1901, p. 1.

IV

THE BITUMINOUS COAL INDUSTRY

Introduction

The bituminous coal produced in Pennsylvania comes from a number of irregularly-shaped fields in the western half of the State and a few small outlying fields in the northern part (Figure 15). When the extent of coal reserves, too, is taken into consideration (Figure 16) the bituminous coal area of Pennsylvania is seen to be a contiguous block of 15 counties with extensions and small isolated areas in at least 13 others. This large area underlain by bituminous coal forms the northeastern end of the Appalachian Coal Region, which in turn is a part of the Eastern Coal Province of the United States.

For many years Pennsylvania was first among the states as a bituminous coal producer, but recently her supremacy has been threatened by West Virginia, the latter actually leading in production in 1927 and 1928 and again in 1931. Although Pennsylvania is far from exhaustion of her bituminous coal resources, the State's production has not kept pace with that of the United States (Figure 17). From 38 per cent of the nation's tonnage in 1900 Pennsylvania's production had decreased to 27 per cent in 1929 and to 26 per cent in 1931. In 1931, according to the United States Bureau of Mines, Pennsylvania produced 97,658,698 net tons of bituminous coal valued at $155,060,000. Over one hundred sixteen thousand persons were employed by the industry in 1931, and the capital invested amounted to nearly five hundred million dollars.

Production is, of course, by no means evenly spread over all of the producing counties. Instead, five adjacent counties in the southwestern part of the State—Fayette, Washington, Allegheny, Cambria, and Westmoreland—account for

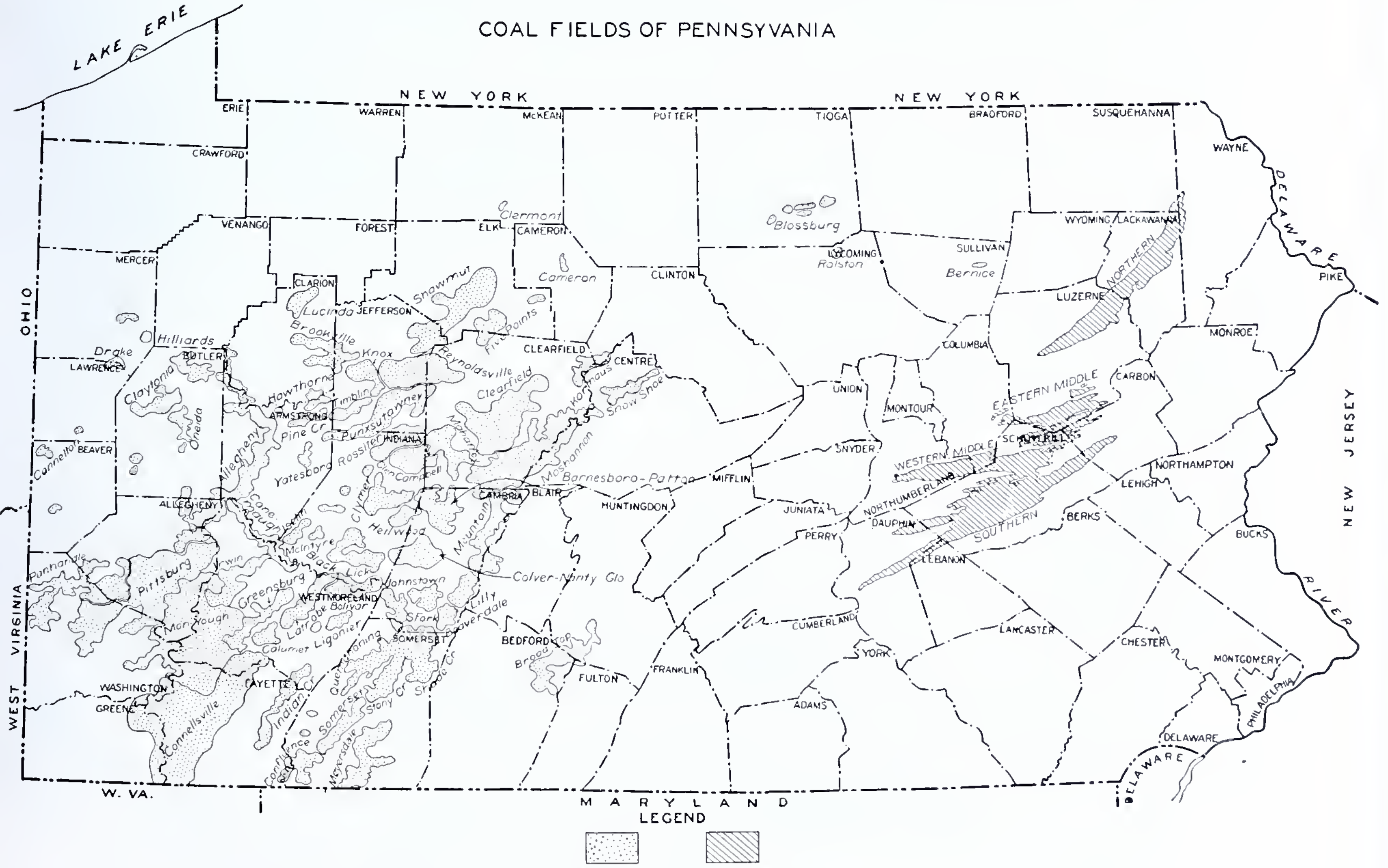

Fig. 15. Map of the producing coal fields of Pennsylvania. (Courtesy of Pennsylvania Geological Survey.)

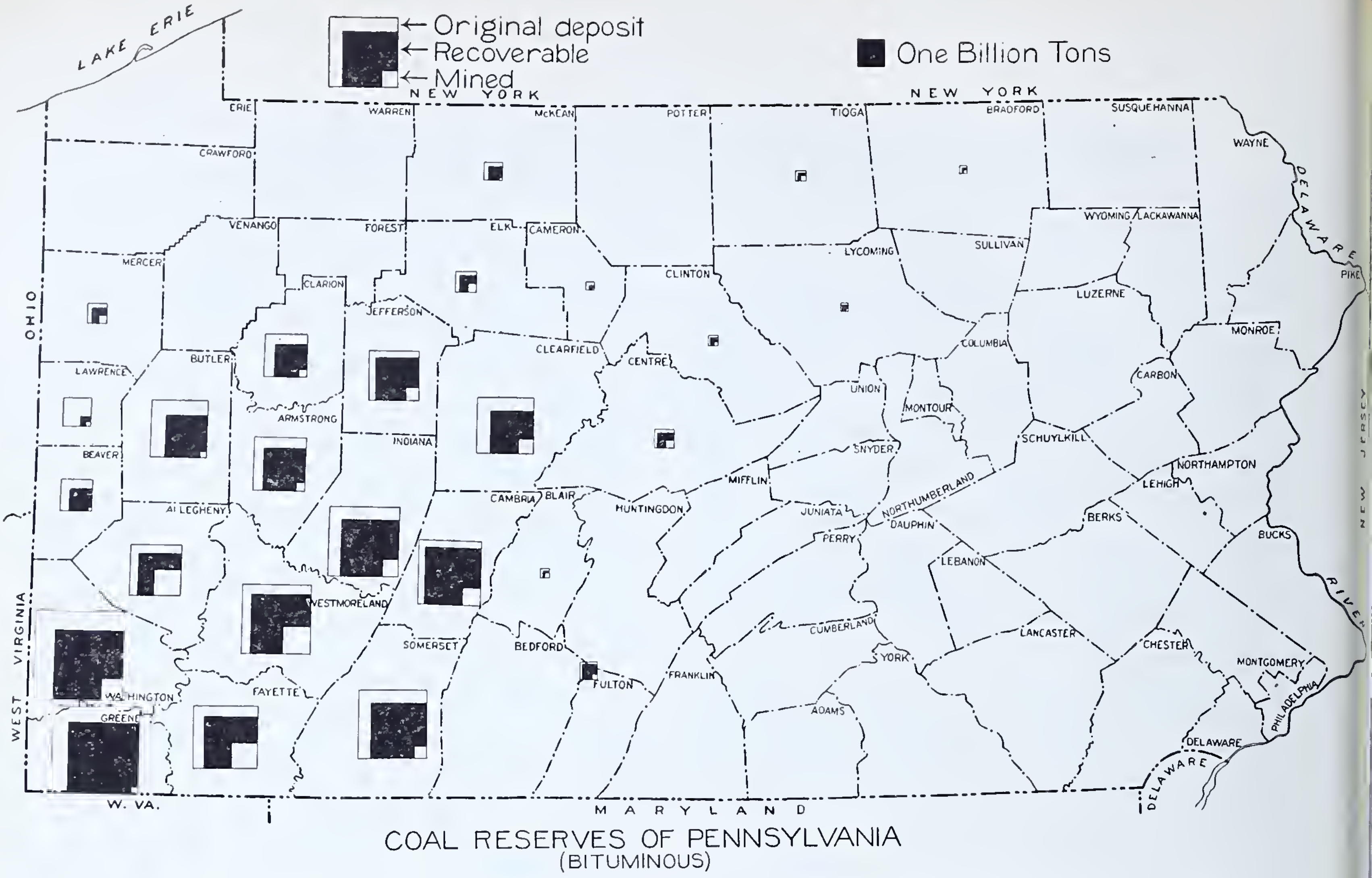

Fig. 16. Bituminous coal reserves of Pennsylvania. (Courtesy of Pennsylvania Geological Survey.)

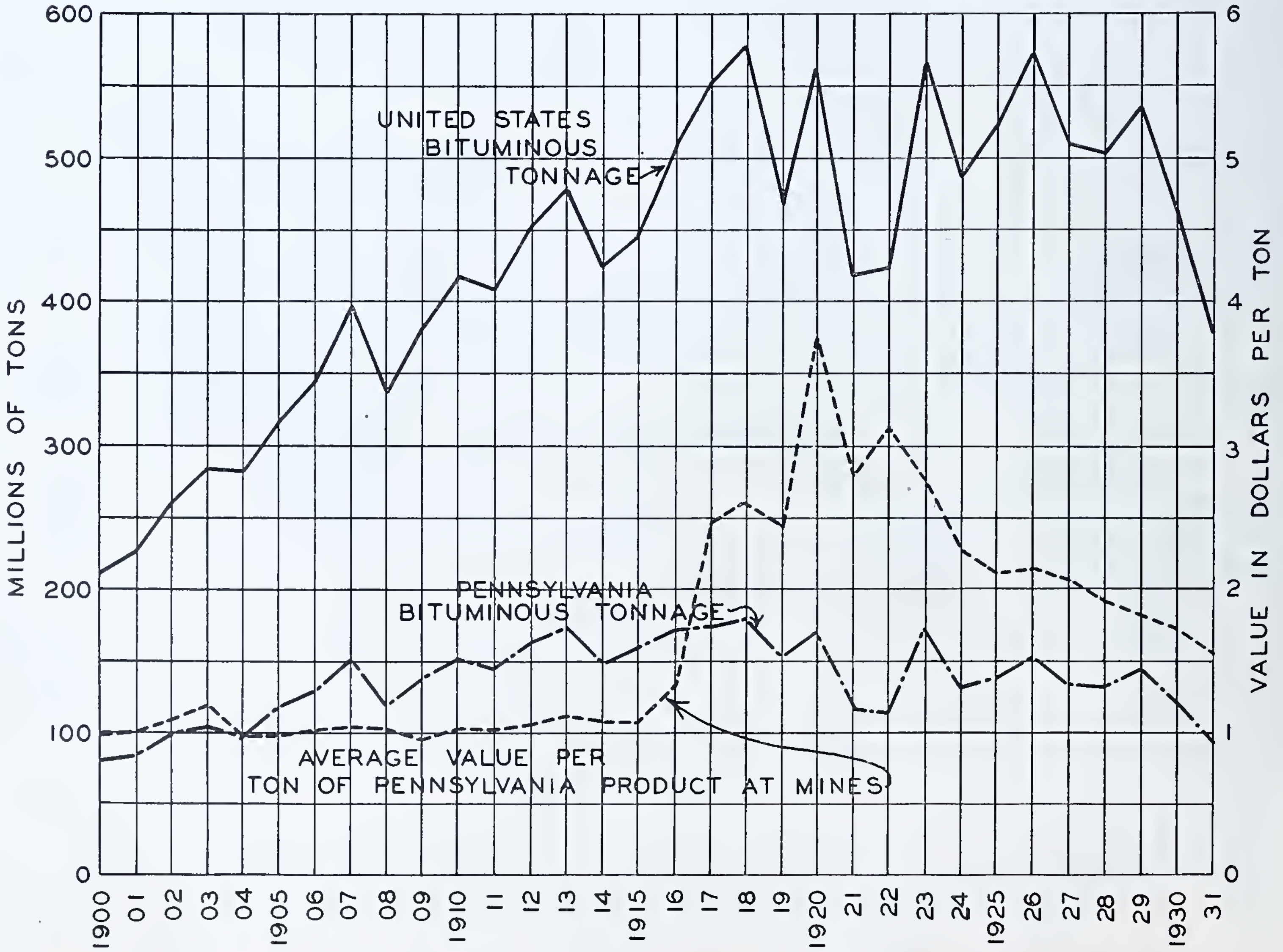

Fig. 17. Production of bituminous coal by the United States and by Pennsylvania since 1900, and average value per ton of Pennsylvania's product at mines during same period. (Data from Mineral Resources of the United States.)

about 70 per cent of the total (Figure 18). It is interesting to note that Greene, the county with the largest reserves, is outranked in production by seven other counties.

The Mining of Bituminous Coal In Pennsylvania

With an extent of approximately 14,000 square miles, the bituminous coal field of Pennsylvania is much less concentrated than the anthracite region. Widely spread over this 14,000 square miles, though locally in clusters, are the many bituminous mines of the State, numbering between 1200 and 1300 in 1931, but variable from year to year.

Mining Methods

The beds in the bituminous coal fields are only mildly folded, dips seldom exceeding five degrees. Mining is, therefore, easier than it is in the anthracite region; and this condition is reflected in almost twice as large a tonnage per man per year in the bituminous fields, as well as in a very much larger development of mechanized mining.

Stripping operations are not an important factor in the State production, amounting to only .4 of one per cent of the total for 1931. Drifts, slopes, and shafts—all are used to reach the coal seams, the determining factors being topography and depth of seam, but drifts are much the most common. Mining, in most cases, follows a room-and-pillar method.

The increased use of mechanical devices in bituminous coal mining is a development that is viewed both with satisfaction and alarm—satisfaction, because it permits cheaper production; alarm, since the introduction of mechanical devices increases the productivity of the mines and displaces laborers. Overproduction is already the curse of the industry, and the disposal of a surplus labor supply is a serious matter.

"Mechanization of mining" refers, ordinarily, both to removal of coal from the working face of the seam and to loading the coal into mine cars for removal from the mine. Pennsylvania has lagged behind the nation in adoption of coal-cutting machines to replace "shooting from the solid" and hand mining, only 74 per cent of the State's total bituminous coal being cut by machines in 1930[1] as compared with 77.5 per cent for

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[1] Tryon, F. G., and Mann, L., Coal in 1929, U. S. Bureau of Mines, p. 751.

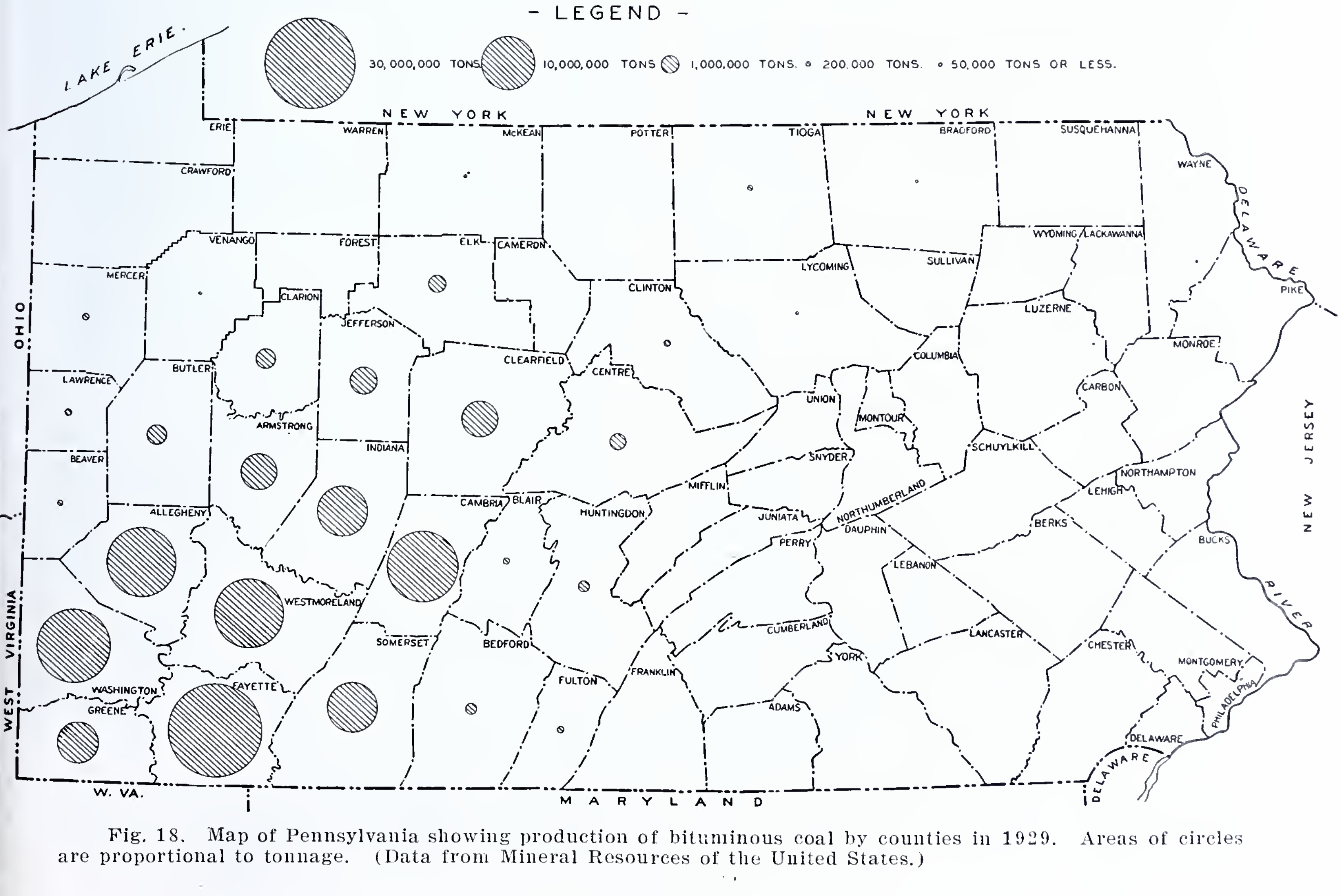

Fig. 18. Map of Pennsylvania showing production of bituminous coal by counties in 1929. Areas of circles are proportional to tonnage. (Data from Mineral Resources of the United States.)

the United States. Between 1913 and 1930 Pennsylvania's percentage of coal cut by machines increased one-third; the percentage for the United States as a whole doubled during the same period. The increase, both for the country as a whole and for Pennsylvania, has come about through an increase in the average output per machine, while the actual number of machines has decreased.

The other form of mechanization, loading of coal into mine cars by mechanical methods in place of hand labor, is far behind coal cutting by machines. "This work, which in the United States involves [annually] lifting a mass of 600,000,000 tons an average height of perhaps 3 feet, has hitherto been done entirely by human muscle. . . . Hand shoveling in the mines has thus remained the last stronghold of heavy labor, resisting more than a century the all but universal tendency toward mechanization."[2] Six per cent of Pennsylvania's deep-mined bituminous coal production was mechanically loaded in 1930 as compared with 10.5 per cent for the country as a whole. This represented a 100 per cent increase over 1929 for Pennsylvania and a 50 per cent increase for the United States. Though mechanical loading has hardly more than started, the interest in it is great, and a continued rapid increase is to be expected.

Not all mines can make use of mechanical loading machines. Behavior of the roof is said to be of primary importance, since close timbering interferes with the lateral movement of the machines. Difficulty of this sort has been had in the Pittsburgh District where a troublesome slate roof has interfered seriously with attempts to use mobile loading machines. Where these machines are proved impracticable some other means of mechanization will probably eventually be found.

Why is it that both in percentage of coal cut by machines and in per cent mechanically loaded Pennsylvania is below the United States average? Probably the principal reason is that the industry was established in Pennsylvania at a relatively early date, before mechanical methods had become popular. The Pennsylvania districts, with their established non-mechanical methods and experienced labor, are naturally slow to mechanize as compared with new districts which are being opened up elsewhere in the country.

Coordination of the operations of tipple, hoist, haulage system, cutting machines, and loading machines requires a higher grade of management than mining operations under the old conditions. Mechanized mining requires also, if economies are to be effected, continuous or nearly continuous operation. Double shifting would be desirable if a low producing cost per ton were the only consideration, but an obvious difficulty is the increased mine capacity in a time of overproduction. More and more, the small high-cost mine will be eliminated in favor of larger mines, operated like factories.

What will become of the surplus labor supply which mechanization is creating? Do the profits from the use of machines belong to capital or to labor? These are questions which extend far beyond the bounds of the bituminous coal mining industry.

The "mechanical revolution" in the bituminous coal industry includes other matters besides the development of machine cutting and mechanical loading. General electrification of mine power has progressed rapidly, haulage, coal cutting, and drilling all being accomplished to an ever-increasing extent by electricity. Such applications of electric power lessen the labor requirements and thus are a part of "mechanization of mining."

Wastes in Production

The average loss in mining of bituminous coal in Pennsylvania is 28.6 per cent, but this could be reduced to about 13 per cent if avoidable losses were eliminated.[3] Certain coal losses are unavoidable. These include coal left under buildings, streams, railroads, and restricted properties; coal left around oil and gas wells; and coal which cannot be removed because of locally adverse physical conditions.

Approximately 15.5 per cent of the total bituminous coal mined in Pennsylvania is unnecessarily lost. Failure to remove pillars, leaving of coal on roof and bottom, leaving of large pillars along property lines, leaving of slightly inferior coal, loss of coal in hauling and preparation both underground and at the surface—these are some of the principal avoidable losses. Loss of coal in beds that have been undermined is less than is commonly believed. It is found that if a coal bed is mined out, the pillars drawn, and the beds given time to settle, higher coal seams may later be mined, although production costs may be high due to the extra timbering necessary.

Economic conditions play a large part in coal losses. Under present conditions of keen competition operators cannot afford to recover "high-cost'' coal. To continue to exist, they must keep their mining costs as low as possible, and this often means passing up slightly less accessible or inferior coal. This works to the advantage of the consumer of today, but the general policy represented is a short-sighted one. As one writer puts it: ''Coal left in the ground or otherwise lost to recovery in the process of production is a form of waste which, deplorable as it is, affects current costs favorably, at the expense of future generations.''

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[2] Tryon, F. G., et al., Coal in 1928, U. S. Bureau of Mines, p. 482.

[3] Sisler, J. D., Bituminous Coal Losses and Mining Methods in Pennsylvania, Pennsylvania Topographic and Geologic Survey, Bulletin M4, 1924, p. 27.

Stream Pollution

The pollution of streams by escaping mine water is a serious problem of the bituminous coal fields. When a coal mine is opened, the underground water coming in contact with air and iron pyrites is rendered more or less acid, and when it is pumped or flows from the mine it is popularly known as ''sulphur water.'' Many miles of streams draining the developed bituminous coal fields have been rendered acid from this ''sulphur water''.

Two boards, one consisting of representatives of the Sanitary Water Board and the other consisting of representatives of the bituminous coal operators, have been making a study of this problem of stream pollution. The following paragraph is based in part upon their preliminary findings.

Although it would be a great service to many areas suffering from stream pollution by mine water, so far no economically feasible method of rendering the acidic ''sulphur water'' more alkaline has been developed. Some aid has come from the coal-mining companies themselves. Certain operators have found that by concentrating the drainage from the mine at a few points of discharge instead of many, ''sulphur water'' may be pumped into main streams or only a few tributary streams. This leaves many tributary streams unpolluted and suitable for public water supply and for fish life. Often new mines may be planned with this idea in mind, and the cost of many small pumps eliminated.

Much has been done, also, when several operators who use a common stream for mine discharge cooperate and so alternate their pumping operations that they minimize peak loads on the streams, thus maintaining a more even degree of acidity of the water. Abandoned mines and worked-out parts of active mines from which drainage flows by gravity are seemingly unabatable sources of stream pollution. It has been found, however, that when mine drainage can be impounded in such abandoned workings, possibly by dams, the higher water level created within the mine keeps air from coming into contact with the iron pyrites and forming more acid. In time, such impounded water will become partially or wholly neutralized. It may then enter the streams of the region without danger to the health or industrial life of the people dependent upon these streams.

Ownership of Mines

The Biennial Report of the Pennsylvania Department of Mines listed about 1300 bituminous coal operators in the State in 1930. Only 100 of these produced more than 200,000 tons apiece, but this 100 accounted for about 80 per cent of the State's total production, while two operators produced between them a little more than 20 per cent. Many companies in many states produce bituminous coal, so the diffusion of ownership which characterizes the industry within Pennsylvania is but a reflection of the condition in the industry as a whole.

Most of the mines are operated by companies or individuals who mine the coal for sale; but a number are ''captive'', that is, are owned by railroads, public utilities, steel manufacturers, or other large consumers. The advantages of consumer-ownership are obvious. Proper quality of fuel and freedom from high market prices are assured. The owners of these ''captive'' mines have gone far toward stabilizing their fuel supply, although, in most cases, they are still dependent upon railroads for delivery of their fuel at the point of consumption. Such ''captive'' mines are likely to be particularly modern and well equipped. For a time the consumer-purchase of mines progressed rapidly, but such developments have been few during the last ten years.

It should be noted in passing that although some mines are owned by large companies which own and operate many mines, there are all gradations from large mines in the hands of large producing concerns down to very small wagon mines. Among the latter are the ''snowbirds'', worked for a while each winter at the height of the demand and springing up in great numbers during a period of abnormally high prices—due to war, a general strike in union mines, or a sudden burst of industrial activity.

Unions and Strikes

The Pennsylvania bituminous coal fields have long been of mixed character so far as labor organization is concerned. As reported by the United States Coal Commission in 1923, the Pittsburgh region and adjacent parts of Western Pennsylvania belonged, with Illinois, Indiana, and Ohio, to the "Central Competitive Field", a region of strong union development. Unionism prevailed also in the northern portion of Pennsylvania's bituminous area and in some small areas elsewhere, as in the Broadtop Field (Figure 15). The nonunion or predominantly nonunion sections of the State included the Connellsville coke region, the Irwin gas, Greensburg, Latrobe, and Ligonier regions in Westmoreland County, and the Somerset-Meyersdale field in Somerset County.

Recent years have witnessed a marked decline in unionism in Pennsylvania's bituminous fields. The union situation described above has faded, and there are now very few companies which are 100 per cent union.

Three major strikes have affected the bituminous coal industry since the War—one in November and December, 1919, one in the summer of 1922, and one lasting from April 1st to October 1st, 1927. In some of these strikes nonunion as well as union miners walked out. In 1922, for example, many thousands of men in the nonunion districts of Connellsville and Somerset struck with the union men.

These strikes will be referred to again later because of their importance in promoting excess mine capacity, in allowing inroads of competitive fuels, and in other ways. Of almost equal importance in the history of the Pennsylvania bituminous coal industry have been the prevailing nonunion conditions in southern West Virginia and eastern Kentucky, Pennsylvania's principal competing region.

Preparation of Bituminous Coal For Market

Preparation of bituminous coal is usually quite simple in comparison with anthracite preparation. However, since the State produces a large quantity of coal, since the producing concerns are of all sizes, and since, moreover, the coal varies considerably in ranks and uses, it is to be expected that preparation of the product will be quite simple at some places and at others quite elaborate.

Bituminous coal preparation consists of two inter-related processes—sizing and cleaning.

Sizing

Coal may be marketed unsized, as run-of-mine, or it may be sized by putting it through screens. A study made by the United States Bureau of Mines[4] shows that in 1927 12.8 per cent of the bituminous coal shipped from mines in Pennsylvania was of prepared sizes; 8.8 per cent was slack or screenings; and the remainder, 78.4 per cent, was run-of-mine or unscreened coal. For the United States as a whole, 29.3 per cent of the coal shipments consisted of prepared sizes. The Somerset, Connellsville, and Central Pennsylvania fields are considerably below the Pennsylvania average in prepared sizes; while the Pittsburgh field is considerably above the State average, 26.5 per cent of its shipments consisting of prepared sizes.

The explanation of Pennsylvania's low rank in coal sizing and of the particularly low rank of some districts within Pennsylvania is found chiefly in the character of the markets for this coal. Connellsville coal is used almost exclusively in coke manufacture (for which no screening is necessary), while in the markets accessible to the Central Pennsylvania and Somerset fields anthracite is readily available and the domestic consumption of bituminous coal is thus curtailed. Within the coal fields themselves, where a somewhat larger use of bituminous coal for domestic fuel is to be expected, most consumers are within wagon or truck-haul distance of some mine, and coal so delivered is not included in "shipments".

The best examples of careful sizing are to be found at those mines and in those districts which cater to the domestic trade, and to the manufacture of illuminating gas. At such mines are to be found screens by means of which the coal may be graded into slack, nut, nut and slack, ¾ inch lump, 1¼ inch lump, and sizes above this depending upon the screens.

Cleaning

Until recent years the separation of impurities from bituminous coal by other than hand picking has received little attention. This has been particularly true in the Northern Appalachian Coal Field where good coal has been abundant and easily obtainable. Since it is less dirty, normally, than anthracite, the cleaning of bituminous coal has often consisted of no more than a picking over by the miner when he loaded his car. The use of shaker screens and picking tables, either in addition to picking over under ground or without this underground work, results in a much cleaner product than where picking over under ground is the only cleaning process. Hand-picking methods are still by far the most common ways in which coal is cleaned; but, under the spur of keener competition and a more discriminating market, mechanical methods of coal cleaning are likely to be much more widely adopted in the near future than they have been to date. The growing use of mechanical loading machines is encouraging this change, since they eliminate the one-time picking over by the miner under ground. A dirtier coal is now delivered to the tipple, while the consuming public is becoming more exacting.

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[4] Tryon, F. G., et al., Coal in 1927, pp. 386 and 392.

Mechanical cleaning applies particularly to coal too small to be picked over by hand. The principle used in the cleaning processes is that the impurities are heavier than the coal, and hence can be separated by air (pneumatic cleaning) or by some wet method.

According to United States Bureau of Mines, 7.8 per cent of Pennsylvania's output in 1929 was mechanically cleaned; and the State ranked fourth in the Union in its percentage of coal mechanically cleaned, being exceeded only by Alabama, Washington, and Colorado.

Coal Pulverization

Pulverization may well be added as a means of preparing bituminous coal, if not for market then for its ultimate use. The value of this means of preparation lies partly in certain types of industrial heat applications, and partly in the saving which may be effected by the mechanical advantages of handling coal in pulverized form.

The desirability of using bituminous coal in pulverized form has been established in certain industries, such as cement manufacture and some metallurgical processes, and the industrial use of pulverized coal is widening. In addition to combustion advantages, low-rank coals are usable in pulverized form where a higher-rank coal would be needed if lump coal were used.

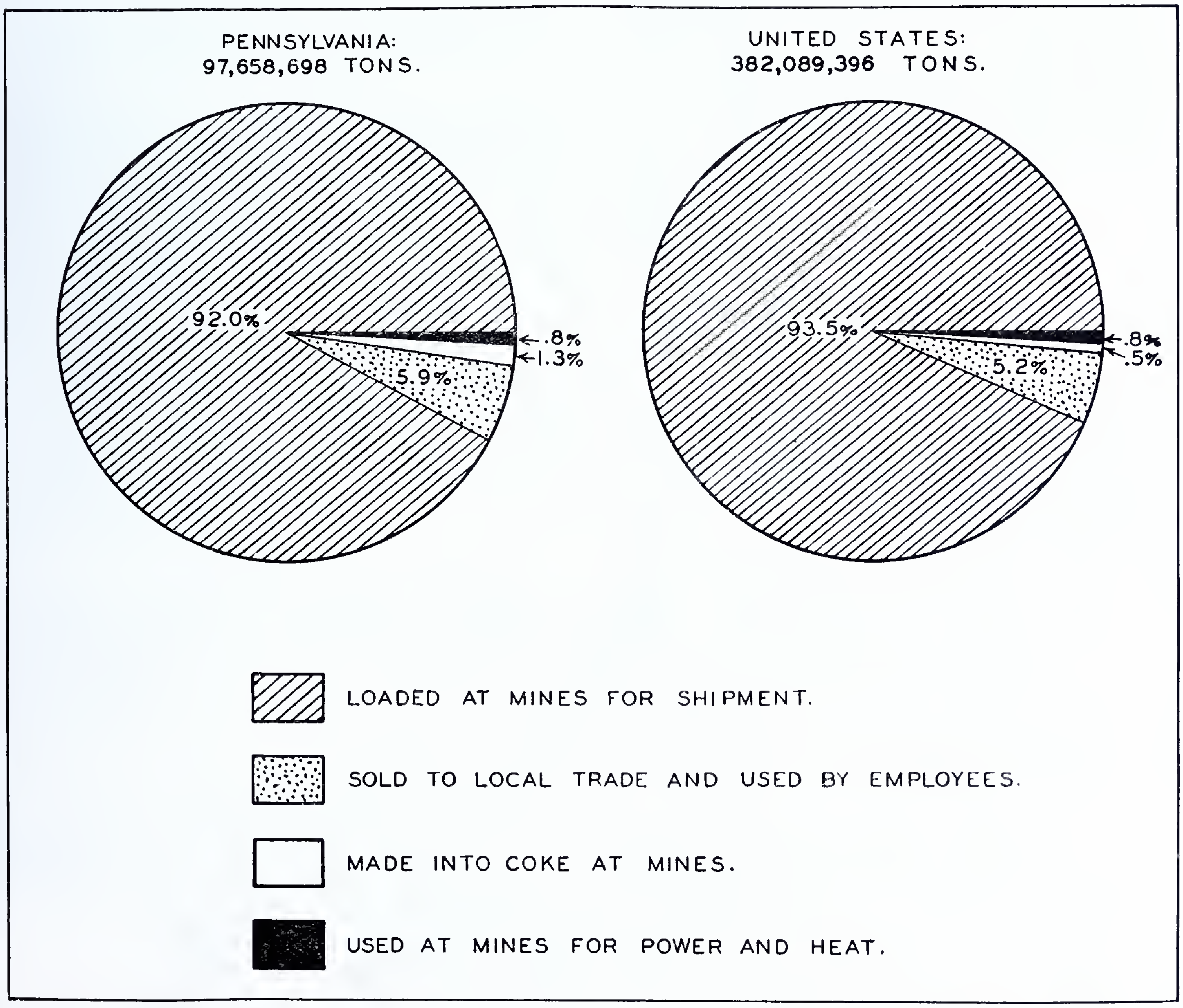

Fig. 19. Disposal of coal as mined for Pennsylvania and for the United States as a whole, 1931. (Data from Mineral Resources of the United States.)

The mobility of pulverized coal at high temperatures is a characteristic which has been attracting much attention. Heating of pulverized bituminous coal causes the fuel to throw off vapors and gases which surround each coal particle and give it great mobility. In this condition it resembles a liquid and obeys the common laws of a liquid. The field of usefulness of coal may be thus enlarged, and it may be made to perform heat operations for which gas or oil was hitherto used. Mixing with gas is another possibility.

Trends In Coal Production

Perhaps the most striking development of recent years in the bituminous coal situation in the United States has been the post-War change in trend of the curves of consumption, and, hence, of production (Figure 17). After rising steadily with few interruptions for many years previous to the World War, and during the War, the country's production curve then began to oscillate without definite trend upward or downward in spite of a continued expansion in the nation's industrial development. Since 1929 the downward trend has been marked. Pennsylvania's production of bituminous coal has shown a fairly steady though gentle decline since 1918.

Utilization of Bituminous Coal

Disposal of Coal at Mines

According to the United States Bureau of Mines, 92 per cent of the total tonnage of bituminous coal produced in Pennsylvania in 1931 was loaded at the mines for shipment (Figure 19). This was somewhat below the United States average (93½ per cent), in part, perhaps, because the proportion of coal made into coke at the mines is larger for Pennsylvania than for the United States as a whole. The beehive process of coke manufacture is still of some importance in Pennsylvania, 10 per cent of the State's total coke being made in that way in 1931, and beehive coking is carried on at the mines.

Consumers of Bituminous Coal in Pennsylvania

In the marketing of many commodities more is known about supply than demand and more about

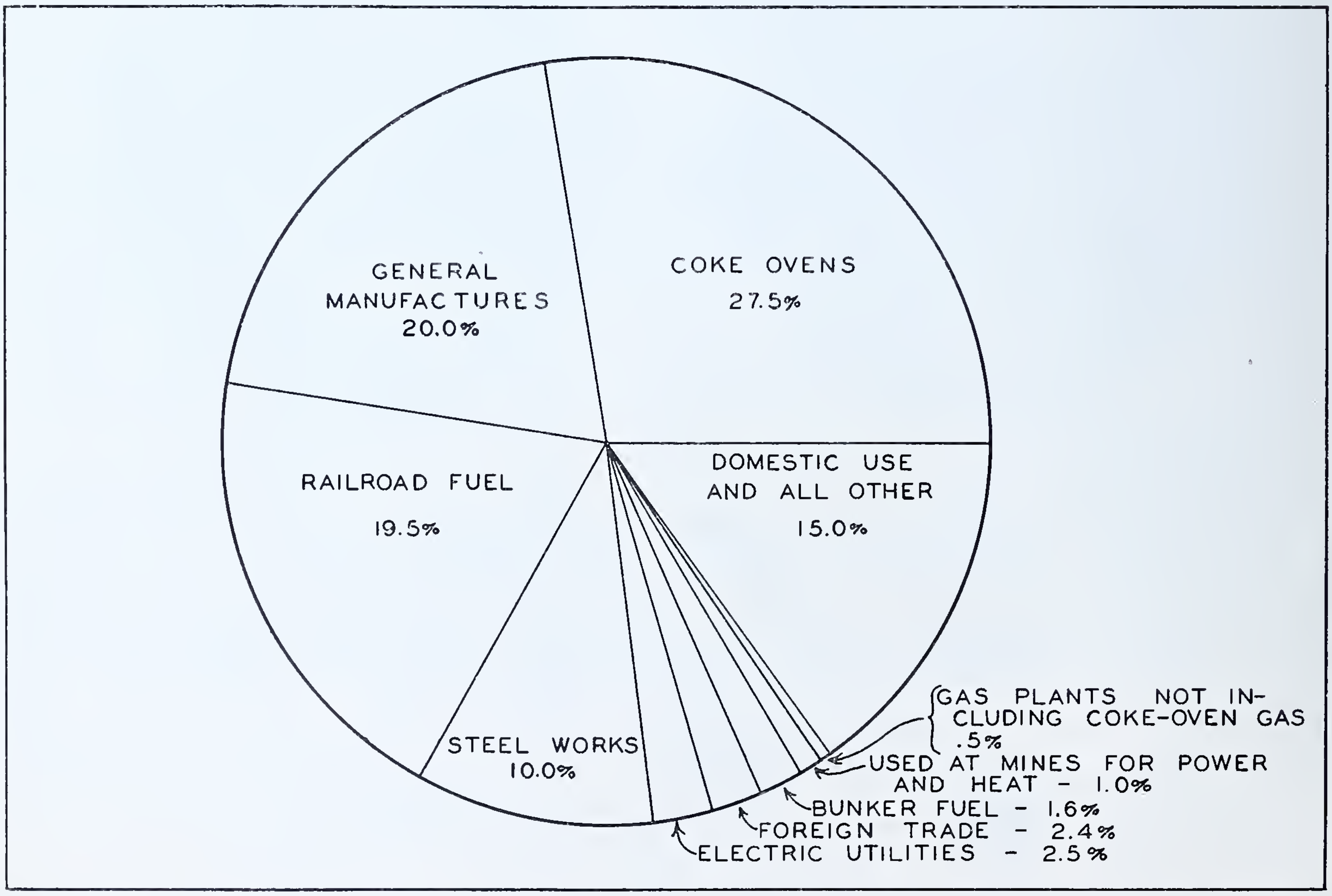

Fig. 20. Uses of bituminous coal in Pennsylvania in 1929. (Based in part upon data in Mineral Resources of the United States and in part upon estimates.)

production than consumption. Bituminous coal is a commodity of this sort. The producer knows how much he ships, but seldom keeps a detailed record of the uses to which his coal is put. If he sells to a wholesaler or retailer he may never know for what purpose his coal is ultimately used. It is only in the case of some of the larger industrial uses, as in coke manufacture, that definite records are kept by the users and that such information is available to the public.

Available data suggest that the iron and steel industry (including the manufacture of coke used in the industry) is the principal consumer of bituminous coal in Pennsylvania (Figure 20), that the railroads are second in coal consumption, and that household use is third. A host of other uses—electric utilities, the bunker trade, exportation to Canada and overseas, gas manufacture, and certain general manufactures (stone, clay, and glass products; metals and metal products other than steel; food products; chemicals and fertilizers; and a number of others)—also account for important amounts.

That competition from other sources of power has been an important factor in this change is clearly shown by Figure 21. Bituminous coal contributed about 70 per cent of the total energy derived from mineral fuels and water power in the United States in 1909; in 1931 its proportion had fallen to about 48½ per cent. Most of this great relative increase in the use of sources of power other than coal represents, directly or indirectly, replacement of coal; but of equal importance in slowing down the demand for coal, and hence coal production, have been advances in fuel efficiency. In each of the principal uses there is the story of reduced consumption per unit of product, particularly since 1917.

The Marketing of Bituminous Coal

Although the markets for bituminous coal are widespread, a large part of the total consumption is concentrated in a relatively small area. According to the United States Bureau of Mines: "Seventy-three per cent of the bituminous coal [consumed in the United States] is used in the industrialized section north of the Ohio and Potomac Rivers and east of the Mississippi; yet even in this region there are areas of sparse consumption, and the great bulk of the tonnage is consumed in a small number of manufacturing centers, of which Pittsburgh, Chicago, Cleveland, New York and northern New Jersey, Youngstown, Detroit, Buffalo, Johnstown, Philadelphia, Boston, Baltimore, Bethlehem, East St. Louis, and Cincinnati are the most important. Some idea of the high degree of concentration of the industrial demand is conveyed by the fact that 85 of the 3,093 counties in the United States consume 51.8 per cent of the coal required by industry, that is, of the coal consumed by coke ovens, gas plants, iron and steel works, railroad shops, and general manufacturing establishments."[5]

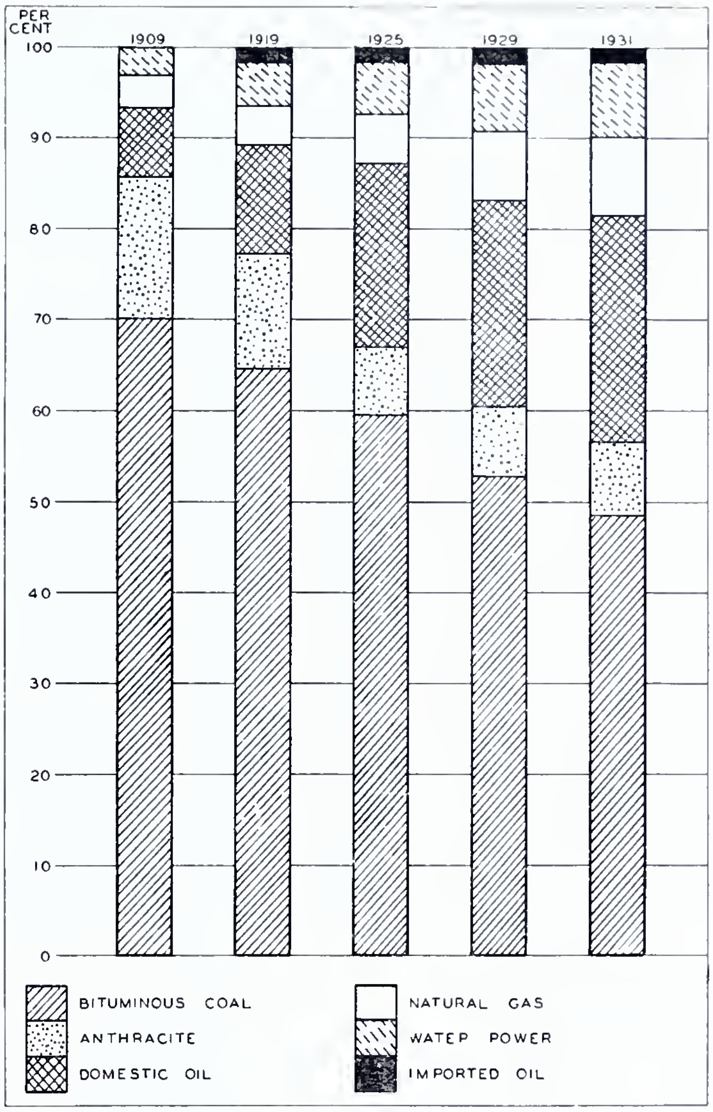

Fig. 21. Changes in sources of annual supply of energy from mineral fuels and water power in the United States since 1909. (Data from weekly coal reports of United States Bureau of Mines.)

The geographic distribution of coal markets varies with the several uses of the coal. One method of attack upon the subject of markets, therefore, is by an analysis of the several uses or "use markets".

Markets In The United States By Uses

Coal Market in the Iron and Steel Industry.

Since a very large part of the coke made from Pennsylvania coal is used in the iron and steel industry, a discussion of the use of coal by the latter must consider the use of coal for coke manufacture as well. The iron and steel industry, directly or indirectly, probably consumed over 30 per cent of Pennsylvania's bituminous coal produced in 1929 (Figure 20). The greater part of the bituminous coal which the industry consumes is used for coke manufacture; the remainder, as steam and gas coal.

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[5] Tryon, F. G., et al., Coal in 1927, p. 406.

A considerably larger proportion of the bituminous coal which Pennsylvania produces is used by the iron and steel industry, either as raw coal or in making coke and by-products used in the industry, than is the case for the United States as a whole. This is true principally because Pennsylvania has a good supply of coal suitable for use by the iron and steel industry, and because Pennsylvania and adjacent states with this industry well established have a considerable demand for coals suitable for this purpose.

Details of the Coke Industry.—The character of coking coal, the source of coking coals in Pennsylvania and elsewhere, the markets for coking coal — are discussed in the chapter on "Coal Processing"; and the markets for the other coals (steam and gas) which are used in the iron and steel industry are essentially the same as those for coke. It is sufficient here simply to point out that while substitution of other fuels for coal has not been important in the iron and steel industry, other influences have been at work which have brought the curve of coal consumption in this industry to a level if not actually to a progressive decline. There has been a steady decrease in the amount of coal used to produce a given amount of product, in other words, a steady increase in efficiency of coal utilization. The principal element in this efficiency increase has been the substitution of by-product coke for beehive coke, with an increasing use of the by-products in the industry as well as of the coke itself. Other factors in the reduction of fuel consumption per unit of product include the growing use of scrap in the open-hearth furnace, the rise of electric steel, and the tendency to purchase electric power from public utilities.

Possible Future Migration of Iron and Steel Industry.—A predicted future migration of the iron and steel industry to the Atlantic Coast is

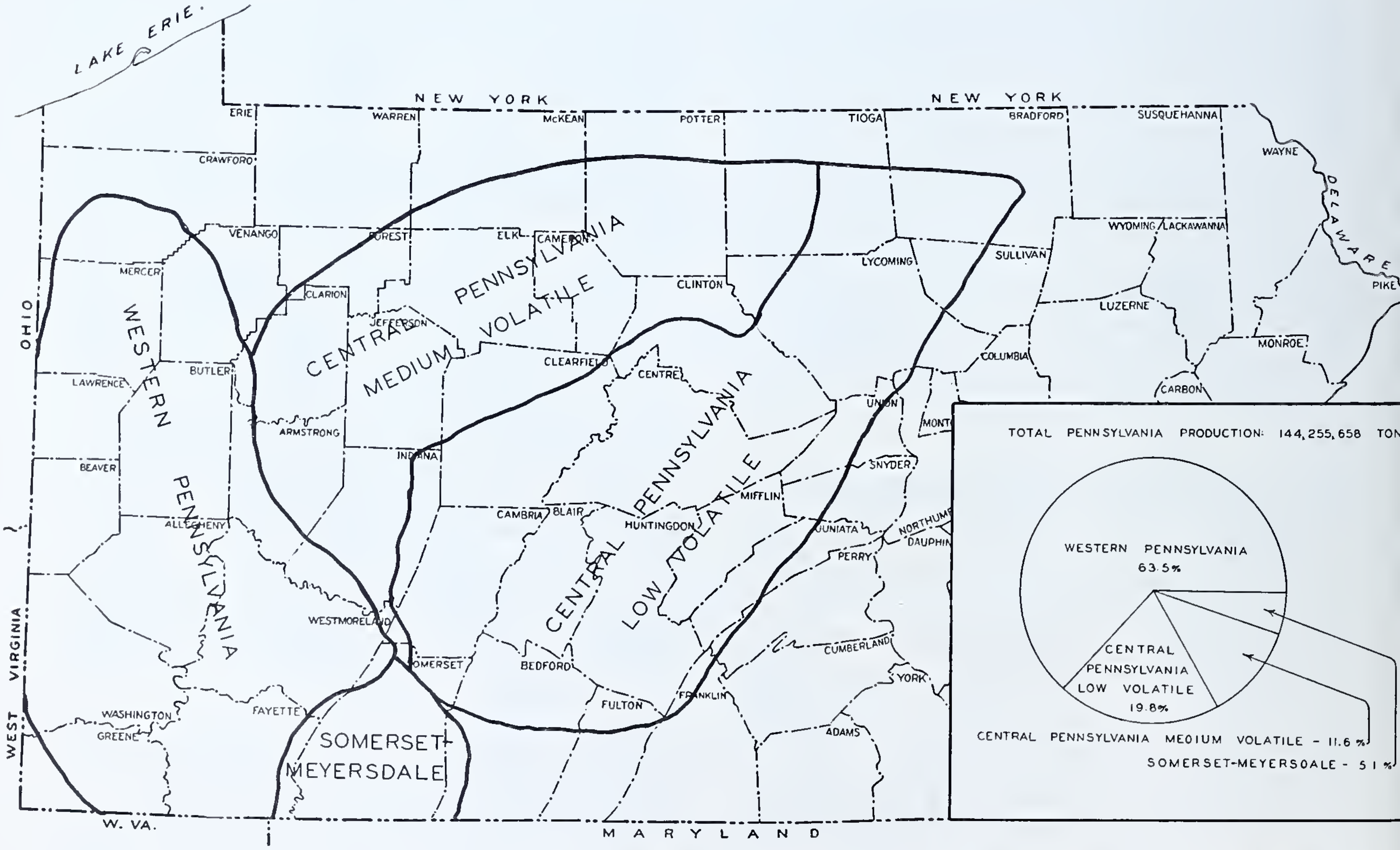

Fig. 22. Map of Pennsylvania showing outlines of the four districts for which production data are given in later graphs, with graph showing the relative importance of these four districts as coal producers in 1929. (Data from monthly coal distribution reports of United States Bureau of Mines. Note that the total 1929 Pennsylvania tonnage as given in Mineral Resources of the United States is 143,516,241; as totalled from monthly coal distribution reports of the United States Bureau of Mines it is 144,255,658. The latter figure is used in those of the following graphs which are based upon the monthly coal distribution reports.)

discussed in the chapter on the iron and steel industry. Such a migration would mean a shift in the locale of coal demand for this industry to the Atlantic Coast, where Pennsylvania's coking coal would meet with severe competition from southern West Virginia-Virginia coals moved by tidewater shipment from Hampton Roads.

Coal Market Presented by Railroads.

Practically any kind of coal can be used for locomotive fuel. Since much of Pennsylvania's coal has special qualities fitting it for more specialized markets, the proportion of the State's total production used by railroads, 19.5 per cent, is less than the average for the United States as a whole. By far the greater part of the coal from Pennsylvania delivered for railroad use reaches its destination entirely by rail.

According to a study made by the United States Bureau of Mines in 1929, Western Pennsylvania (Figures 22 and 23) contributed the largest tonnage of all-rail deliveries of railroad fuel originating in Pennsylvania during that year, with a total of about 14,600,000 tons; the Central Pennsylvania Medium-volatile district was second among the Pennsylvania fields with 6,851,000 tons; the Central Pennsylvania Low-volatile district next with 5,424,778 tons; and the Somerset-Meyersdale district last with only 894,000 tons. The railroad-fuel market is, however, of considerably greater relative importance to the Central Pennsylvania Medium-volatile field than to any of the others. Thus, coal delivered for railroad use made up 41 per cent of the total production of the Central Pennsylvania Medium-volatile district, 19 per cent of the Central Pennsylvania Low-volatile district's production, 16 per cent of that of Western Pennsylvania, and only 12 per cent of the Somerset-Meyersdale production. In addition to all-rail deliveries as described, some of Pennsylvania's tidewater deliveries are used by railroads in New England, and some of the coal moving as lake cargo is delivered to railroads in the lake region.

The same Bureau of Mines study brings out some interesting facts regarding shifts in the sources of railroad fuel since 1917. Two broad changes are evident. One is a shift from medium and low-volatile to high-volatile coals, which offer certain advantages for locomotive use. Thus, more Western Pennsylvania coal was used by railroads in 1929 than in 1917, but only about half as much railroad fuel was procured from Central Pennsylvania and the Somerset-Meyersdale field in 1929 as in 1917. The second change is a shift within the high-volatile coals themselves

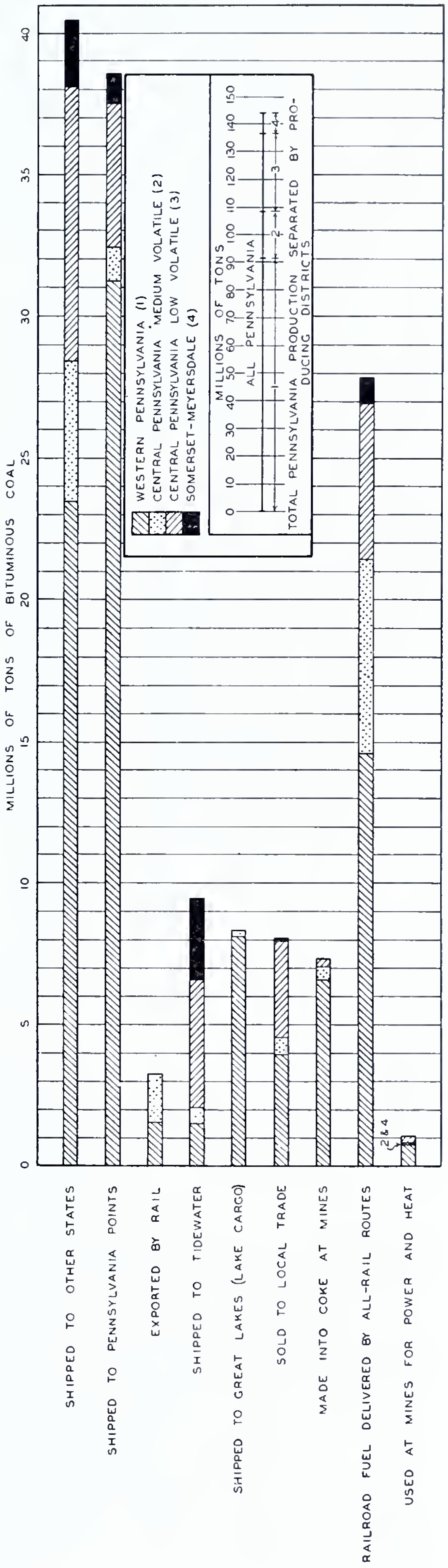

Fig. 23. Sources of bituminous coal for various uses produced in Pennsylvania in 1929. (Data from monthly coal distribution reports of United States Bureau of Mines.)

away from the northern and western fields and toward the southern fields. While the 1929 purchases of railroad fuel in Western Pennsylvania were 122 per cent of those of 1917, Eastern Kentucky and Tennessee railroad sales were 139 per cent of those for 1917, and the corresponding figures for the other southern high-volatile districts were: Western Kentucky, 150 per cent; Southern West Virginia High-volatile district, 168 per cent; and Northern West Virginia, 191 per cent.

The most striking feature of the railroad-fuel market has been the decline in total bituminous coal consumption by the railroads within recent years. Although motor vehicles have been giving serious competition, this does not explain the decline in bituminous coal use by railroads, since the physical volume of rail transportation has actually been increasing in spite of the competition. The explanation is to be found, instead, in increased fuel efficiency and in competition of other fuels. The pounds of coal used per transportation unit have been steadily decreasing, and there is reason to believe that there will be still further decrease. Competition with other fuels has taken the form, principally, of some increase in the use of fuel oil by railroads. However, this increase has not been great in the sections of the country normally served by Pennsylvania's bituminous coal; and has been offset, somewhat, by a decline in the use of hard coal by the anthracite carriers, which have turned more and more to bituminous coal, releasing anthracite for uses to which it is especially adapted. The decrease in coal consumption seems, therefore, to be principally a response to increased efficiency.

There seems to be little prospect of much increase in coal consumption by railroads in the future. Use of highways and waterways may decrease the total railroad traffic, and even if the highways and waterways are put on more equitable terms of competition by taxes or other provisions, it is unlikely that railroad traffic will grow as rapidly in the future as it has in the past. There is a growing use of oil, gas, and electricity relative to coal, and these may be transported by pipe lines and transmission wires instead of by railroad. Industries are showing some tendency to migrate to the sources of raw materials or to points nearer centers of consumption, thus saving freight. Progress in fuel efficiency is likely to continue. On the other hand, however, there seems little prospect of fuel oil making serious future inroads on the railroad coal market, and electrification of railroads is not proceeding rapidly enough to seriously curtail the coal market.

Heating of Houses and Other Buildings.

Though Pennsylvania contains bituminous coals which are satisfactory for domestic purposes and for the heating of buildings in general, this use of the State's bituminous coal is not of as great relative importance as the same use for the United States as a whole. Reasons for this lower relative importance are to be found in the excellence of certain of the Pennsylvania coals for industrial purposes, in the large proportion of fine sizes into which some of Pennsylvania's low-volatile bituminous coals break, and in the competition of anthracite which Pennsylvania bituminous coals must meet.

Little information is available as to where coal used for domestic (and other building heating) purposes originates or where it is ultimately used. In the aggregate, a considerable amount of bituminous coal must be used thus in Pennsylvania, but the amount is not as great as that used for similar purposes in some of the states farther from the anthracite supply. The state of New York, too, uses some Pennsylvania bituminous coal for heating homes and other buildings, and a part of the bituminous coal from Pennsylvania which reaches tidewater (mainly from the Central Pennsylvania and Somerset-Meyersdale fields) eventually is so used in New England. In the eastern New York and New England markets and in eastern Pennsylvania, anthracite from eastern Pennsylvania and low-volatile West Virginia and Virginia bituminous coals coming by tidewater from the south play more important parts in the domestic fuel market. A considerable part of Pennsylvania's lake-cargo coal, which originates chiefly in the Pittsburgh district, is sold for heating buildings in the Lakes region, as is some coal moving west from Pennsylvania by all-rail haul. These rather general conclusions about the location of the house and building heating markets are all that available data permit.

Within recent years the use of coal for heating houses and other buildings appears to have been increasing. With a rising standard of living people are requiring more and more fuel to warm their homes, and, moreover, to warm schools, places of amusement, office buildings, and other buildings outside the home where people are spending an increasing proportion of their time. The per capita fuel consumption is increasing. Most of this increase has gone to bituminous coal rather than to anthracite, since the larger buildings tend to use bituminous coal, while anthracite is being restricted more and more to the heating of detached houses. Growth in the use of apartment houses has given a still further stimulus to the bituminous coal industry. This trend toward increased use of bituminous coal for domestic and other heating is said to have brought about an increased interest in screening and sizing in many bituminous coal districts.

In the field of house and other building heating, bituminous coal, although dominant, encounters serious competition. The efforts of anthracite to extend its uses and markets have already been pointed out. Pennsylvania bituminous coal fields, particularly, feel this competition from anthracite, because of proximity of the two industries in the State, and because eastern Pennsylvania and adjacent areas in other states would normally be bituminous coal market territory if it were not for the presence of the anthracite. Fuel oil and natural and manufactured gas also compete with bituminous coal for the heating market. Oil-burning heating systems are being installed in houses which formerly used bituminous coal, and especially in new houses. Convenience dictates the substitution of gas or fuel oil for bituminous coal, and a rising standard of living has made people willing to pay the higher cost of these more convenient fuels. The use of coke for heating buildings has been increasing rapidly, and bids fair to continue to do so, but this is, in fact, merely another way of using bituminous coal, since all but a very small proportion of the coke is made from bituminous coal. Moreover, it is a gain for the Pennsylvania bituminous coal industry, since Pennsylvania's coal is used so widely in coke manufacture.

Bunker-fuel Market.

Because of space and cargo considerations, coals used for steamship fuel are such as give the highest heat yield per unit of bulk and weight. Anthracite answers these needs very well, but its cost is too great for a bunker fuel. Therefore, high-rank bituminous coals are used, delivered as run-of-mine. The low-volatile or ''smokeless'' coals of Central Pennsylvania and Somerset County are highly prized as bunker fuel, and Pennsylvania leads in this trade, although southern West Virginia coals are also important. Unfortunately, however, the bunker-fuel market is small, the total from all producing areas (in Pennsylvania and elsewhere) shipped to tidewater for this use in 1931 being less than four million tons.

The most striking trend in the bunker trade within recent years has been the increased use of fuel oil by steamships in place of coal. This may eventually seriously curtail the bunker-coal business.

Electric Utilities Market.

The two main considerations in selecting coal for electric utilities are the price per effective heat unit and the dependability of the source of supply. Except where local regulations or smoke ordinances prevent, practically any type of coal can be used for this purpose. It follows that coal from all the bituminous area of Pennsylvania is used by electric utilities to some extent, and that a considerable amount of Pennsylvania's coal is so used in other states.

Central Pennsylvania coals satisfy much of this demand in the cities of eastern Pennsylvania, of New York State, and of New England, the coal reaching the latter partly by ocean. ''Smokeless'' coals are particularly in demand in these built-up eastern sections. Coals from western Pennsylvania, particularly from the Pittsburgh district, are marketed for electric utilities use in the states farther west, partly by all-rail movement and partly by rail and lake cargo.

Several trends are noticeable and of interest in the use of coal by electric utilities. One of these is the growth of central stations serving many manufacturing establishments, and the shutting down of isolated power plants formerly operated by each of the factories which now purchase from the central plant. With this greater development of central stations has come greater efficiency. Coal consumption in electric utilities has increased much more slowly than electric power production, and, in fact, has been about stationary during the last few years. In 1902 the average consumption of coal per kilowatt-hour in the United States was about 6.6 pounds; in 1930, 1.62 pounds. Competition of oil and gas, another factor in keeping down coal consumption by the electric utilities, is much less important than increase in efficiency. Similarly, water power, although competing with coal in this market, cannot have been very important in the decrease in coal consumption. Besides the increased centralization of power development, recent years have witnessed a rapid enlargement of the domestic market, both in the number of customers served and in the amount of electricity used per customer.

What of the future of coal use by electric utilities? Extension of markets in manufacturing, increase in use of electricity in the homes particularly by the use of new electrical appliances, electrification of railroads, electrification of farms, and use of off-peak load in electric heating of houses—all have been suggested for the future. Increased use of electrical appliances in homes and electrification of farms would extend the use of coal; but heating of houses by electricity, electrification of railroads, and increased electrification of manufacturing would probably mean a decrease in coal use, particularly since some of the electricity would be generated by use of water power. It is doubtful whether use on farms will become very important, since transmission costs are high and many farm operations could not make use of electric power. The heating of houses by electricity, although still in the experimental stage, promises to be of importance in the future.

General Manufactures as a Market for Coal.

The markets for coal in general manufacturing (excluding steel, coke, railroad repair shops, and gas and electric utilities) are much the same as those for public utilities. Coal from the Pennsylvania fields — from Central Pennsylvania, Northern Pennsylvania, the Somerset-Meyersdale field, and even from Western Pennsylvania—serve the big industrial markets of eastern Pennsylvania, New York, New Jersey, and New England partly by direct rail haul and partly, as in the case of New England, by rail haul and tidewater shipment. Coal from Western Pennsylvania, particularly from the Pittsburgh area, serves the general manufacturing industries of western Pennsylvania and industrial markets in the states to the west, partly by direct rail haul and partly by rail haul and lake-cargo shipment.

Naturally, the coal demands differ with the particular type of consumer. For instance, the cement industry uses high-volatile, low-sulphur bituminous coal, much of the needs of the Lehigh Valley being met by the Fairmont region of West Virginia. For making brick and similar products high-volatile, non-coking coals are required, and for burning the more highly-glazed products coals must be of high heating value.

The trends of coal use in general manufacturing are much like those in public utilities. Since manufacturing depends to a considerable extent upon electric power, it is not surprising to find that more and more general manufacturing plants are shutting down their isolated power plants and depending upon central stations. With this has come greater efficiency and a saving in the coal used for power. It has been pointed out that those general manufacturing industries which use coal chiefly as power have used less and less coal within recent years, chiefly because increased use of central stations has meant increased efficiency. On the other hand, those industries which consume fuel chiefly by direct application of heat (e. g. cement, clay products, et cetera) have shown a fairly steady increase in coal consumed.

Market for Coal in Gas Manufacture.

Gas manufacture is discussed in the chapter on Coal Processing.

Coal Used at Mines For Power and Heat.

The proportion of total bituminous coal output used as fuel at the mines, never a large figure, has been decreasing within recent years, amounting in Pennsylvania in 1931 to but eight-tenths of one per cent of the State's total production. Growth in the practice of buying power from central electric stations accounts for most of the decline. This same tendency for the centralization of electric power manufacture has been mentioned earlier in connection with electric utilities and with general manufacturing.

Foreign Trade.

Export trade in bituminous coal is discussed later under "Tidewater Bituminous Coal Shipments".

Movements of Coal From The Pennsylvania Bituminous Coal Area

Very little bituminous coal moves from the Pennsylvania fields into West Virginia, but in almost every other direction there are important coal movements.

Bituminous coal from Pennsylvania fields finds important markets in states farther west. Naturally, the Pittsburgh district has the lion's share of this trade; but a considerable amount, also, comes from the Connellsville district, and some from the other districts of the State. This westward movement of coal is of two types. Approximately 10 per cent of the State's total production went by rail and river to markets west of Pennsylvania in 1929; while about 6 per cent went by rail to Lake Erie ports, to be shipped from there by lake steamers to various lake points. This latter coal may be consumed at the receiving ports or may be shipped by rail from them to its ultimate destination.

Westward Movements by All-rail Haul and by River Barge.

Rail haul being costly it is not surprising to find that most of the coal moving west from Pennsylvania entirely by this means does not travel far; but, instead, finds its chief markets in Ohio, where much of it is made into coke for the iron and steel industry. A relatively small amount of coal travels still farther west by all-rail haul reaching northern Indiana, northern Illinois, Michigan, and Wisconsin, and some coal from the western districts of Pennsylvania goes by barge to various points down the Ohio.

The Lake-cargo Bituminous Coal Movement.

That coal which goes by rail to the south shore of Lake Erie and is there loaded into lake steamers is referred to as "lake-cargo" coal. The portion of this coming from Pennsylvania originates in much the same districts as the all-rail coal and river-barge coal moving west, by far the greater portion coming from the Pittsburgh district (Figure 23). Pennsylvania is not, however, the only state shipping coal to Lake Erie for the lake-cargo trade. In 1929 it accounted for only 21 per cent of the total lake-cargo coal (Figure 24). In the same year Eastern Kentucky contributed almost as much to this trade as did Pennsylvania, while West Virginia shipped about 52 per cent of the total. Ohio sent less coal by lake cargo than Eastern Kentucky, and Tennessee and Virginia were very minor participants in the trade.

The bituminous coal assembled at the south shore of Lake Erie as lake cargo in 1929 reached its principal markets in Canada, Wisconsin, Minnesota, Michigan, the Chicago District of Illinois and Indiana, and New York State, although the Dakotas, Ohio, and a number of other states received some. Coal thus delivered is for railroad, industrial, and domestic use, but there are no exact data available as to the relative proportions going to each of these three groups of uses.

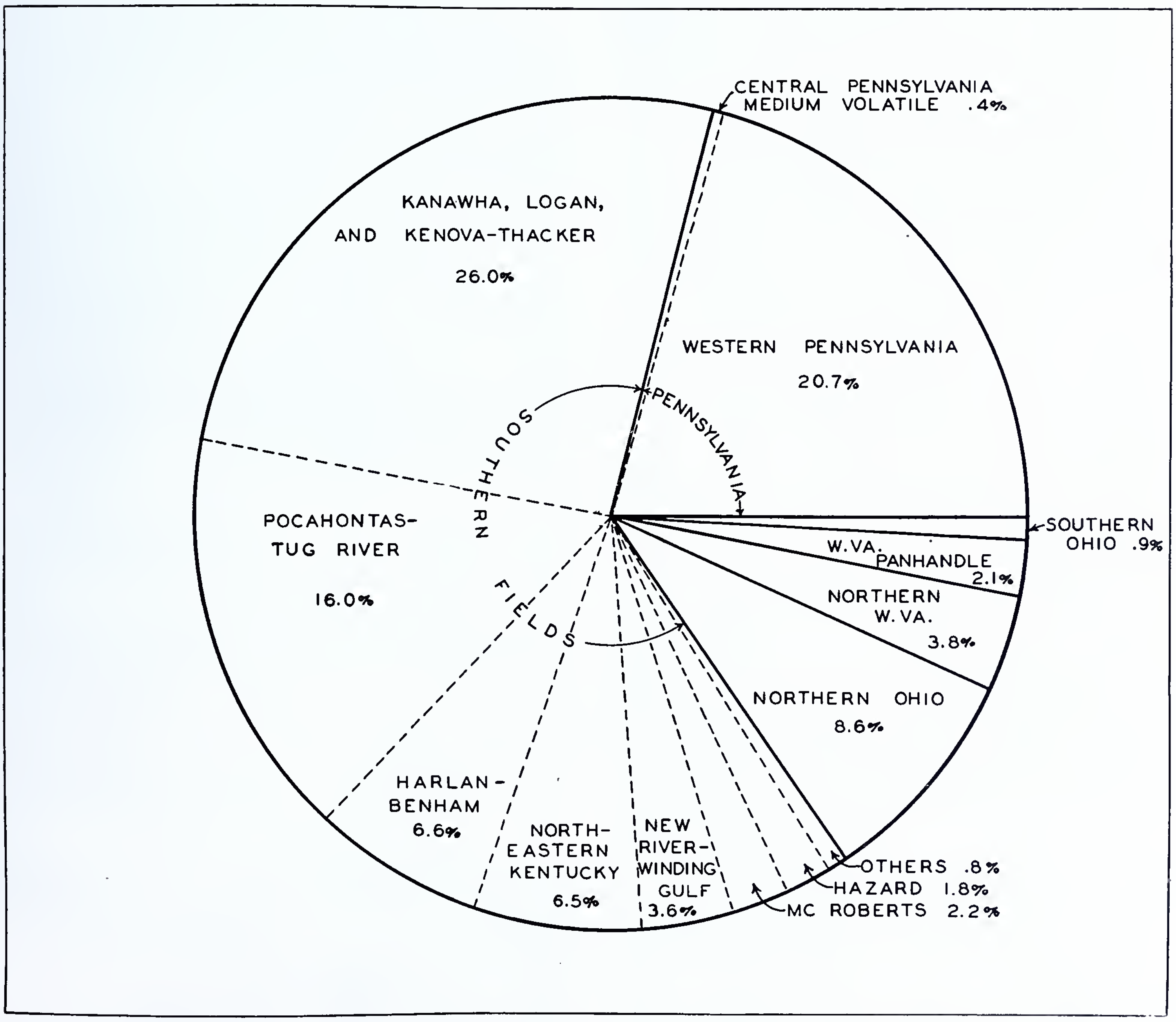

Fig. 24. Sources of lake-cargo bituminous coal, 1929. (Data from monthly coal distribution reports of United States Bureau of Mines.)

The lake-cargo coal business is highly seasonal, being carried on in summer months when the lakes are open for navigation. Since the peaks of domestic and industrial consumption of bituminous coal invariably come in winter, the lake-cargo trade is of great value to the mine operator, since it comes at his dullest season. The resulting year-round character of the production means a lower unit cost than would be possible without the lake-cargo trade.

Bituminous coal which enters the lake-cargo trade comes from three districts:

(1) The "northern" fields in eastern Ohio and western Pennsylvania.
(2) The "southern" fields in southern West Virginia, eastern Kentucky, western Virginia, and Tennessee.
(3) The "Fairmont" area in northern West Virginia midway between the other two.

The Pennsylvania-Ohio district is about 160 miles from the Lake ports, the West Virginia-Kentucky district about 425 miles, and the Fairmont district about 250 miles. In view of the conditions which have for some time prevailed in the bituminous coal industry, and in view of the size and favorable seasonal characteristics of the lake-cargo trade, it is not surprising that competition between the three producing districts for the lake-cargo business has been for a long time severe. The struggle has been particularly keen between the northern and southern fields (Figure 25), the "Fairmont" area playing a relatively minor role.

It would seem, at first glance, that the southern fields, lying more than twice as far from the Lake Erie ports as the northern fields, would be handicapped by a much higher freight cost. There was, however, little difference in the freight cost per ton from the two areas to Lake Erie ports before 1912[6], at which time the case was brought

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[6] There was, of course, a great difference in the freight cost per ton-mile which was more than twice as high from the northern district. Since, on a long haul, handling charges are distributed over a greater number of miles, it is apparent that ton-mile rates should be somewhat higher from the northern fields.

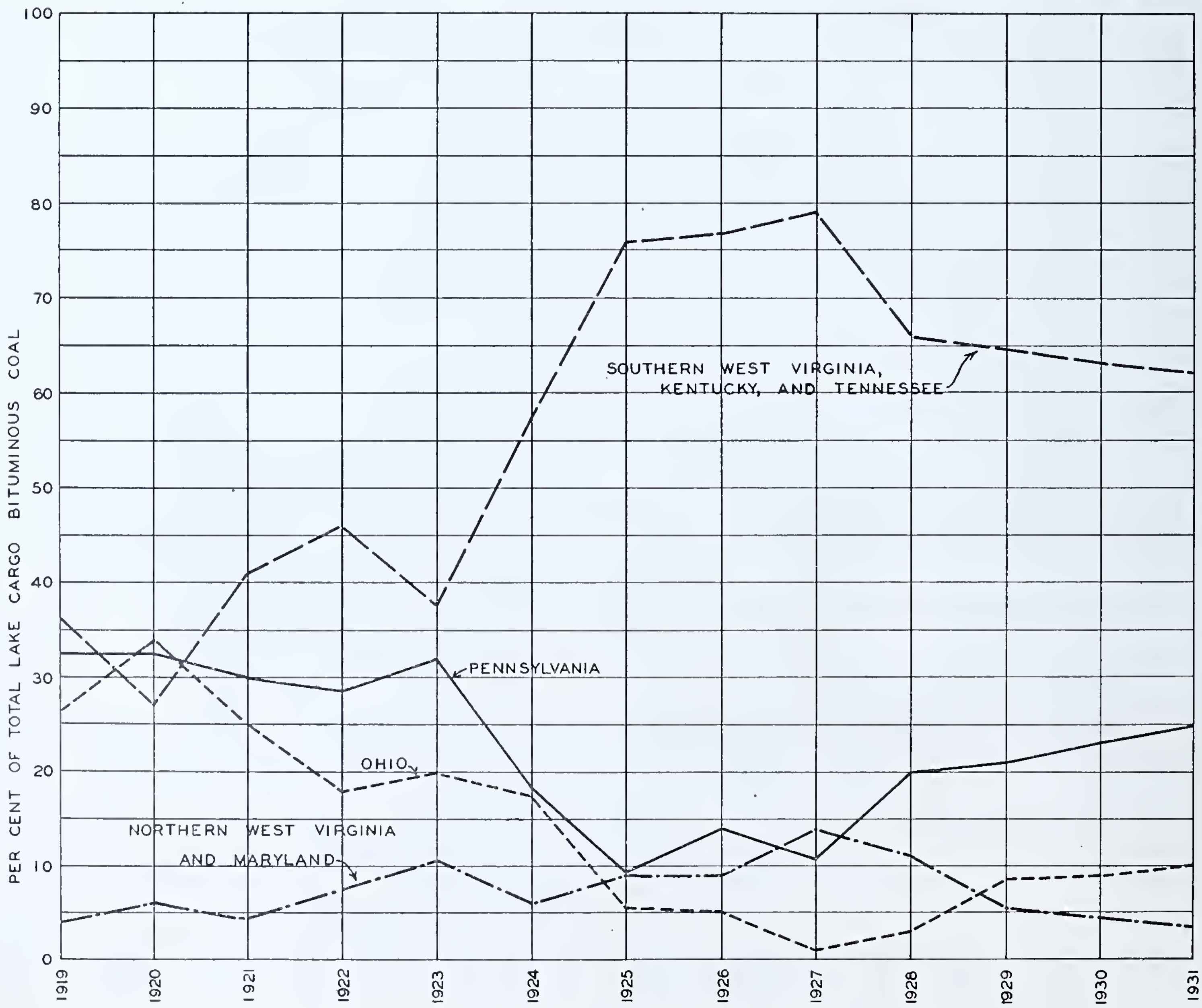

Fig. 25. Recent trends in the importance of each of the several groups of fields concerned in the lake-cargo trade. (Data from Ohio Bureau of Coal Statistics and Ore and Coal Exchange.)

before the Interstate Commerce Commission by the northern fields who saw an increasing proportion of their lake-cargo trade going to the southern operators. The northern group contended that they were entitled to a lower freight rate than the southern fields, in other words, that a differential in favor of the northern fields should be established. The amount of this differential has been the subject of much argument and of many hearings before the Interstate Commerce Commission. Suffice it to say that the differentials now in effect were arrived at by compromise in 1929. As compared with the Pittsburgh district, the Fairmont district pays a differential of 20 cents, and the Kenova-Thacker-Kanawah area of West Virginia 35 cents. Thus, the freight cost per ton from the Pittsburgh district (typical of the northern fields) to Lake Erie ports is $1.46, from the Fairmont area $1.66, and from the Kenova-Thacker-Kanawah area (typical of the southern group of fields) $1.81.

Much has been said on each side of the lake-cargo rail-rate controversy. The southern fields have been the low-cost producers, having the advantages of lower capitalized costs of acreage, materially lower taxes, more economical methods of handling and extracting coal, and lower (since largely non-union) wage scales. The Pittsburgh district, typical of the northern fields, complains of high taxes, high cost of coal lands, high cost of living, high wages, and difficulty from draw slate. The northern fields contend that they should have the lower freight rates to which their proximity to the Lake entitles them, since this same factor of location results in the high costs described.

The southern fields, on the other hand, in protesting against any increase in differentials, say that the railroads carrying the coal from these southern fields are predominantly coal-carrying railroads, in contrast to the northern roads with their divided interests. The southern operators contend that the railroads serving the southern fields, because they were built with the primary purpose of carrying coal, have better grades, better equipment for loading and carrying coal, and other advantages which give them much lower costs than those of the northern roads; and that, therefore, it is right that the ton-mile rates from the southern fields should be lower. They say, for instance, that the costs of handling coal for a road like the Norfolk and Western are less than half those for a road like the Pennsylvania. The northern fields balance against this the fact that the railroads bringing coal from the southern fields have little return cargo, while the roads from the northern fields do not suffer from this handicap. In all this controversy the railroads have acted in close accord with the operators of their areas, since the major interest of these roads has been to get more of the lake-cargo trade for their tributary areas.

The northern fields are even now pressing their claim to a higher differential than the present one, pointing out that they have lost much of their lake-cargo coal trade to the southern fields, and that the present rate structure does not properly reflect the location advantage of the northern fields. Although the most recent claim for a greater differential has been denied, the northern fields have increased their lake-cargo coal business somewhat since 1927. At that time the Jacksonville agreement expired, and the lower wage scale which has since been in effect has allowed more effective competition with the southern fields.

All-rail Movement to the North and East.

It has been pointed out that bituminous coal from Pennsylvania moves northwest and north to the south shore of Lake Erie for loading as lake-cargo coal. Some coal moving north does not enter the lake-cargo trade, but, instead, reaches consumers in western New York State and northwestern Pennsylvania entirely by rail. A similar though larger all-rail movement carries coal to markets in eastern Pennsylvania, New England, eastern New York, New Jersey, and, to a minor extent, in Maryland, Delaware, and the District of Columbia. In the New England trade these rail shipments of bituminous coal are losing in relative importance to tidewater coal (Figure 11).

Northern Pennsylvania, Central Pennsylvania, and the Pittsburgh district are the chief contributors to the western New York movement; Central Pennsylvania is outstanding in all-rail movements to the east. Most of the coal sent east by all-rail movement is used for industrial purposes for most of which the Central Pennsylvania coals are well suited. They have a freight advantage, too, since Central Pennsylvania is the field closest to the important industrial region of which New York City is the focus.

Tidewater Bituminous Coal Shipments.

Some of Pennsylvania's bituminous coal (Figure 23) is shipped by rail to New York, Philadelphia, and Baltimore, and there dumped over piers into boats or barges. New York is the principal dumping port for Pennsylvania's tidewater coal, Philadelphia being considerably less important, while Baltimore, though the terminus for about as much tidewater coal as Philadelphia, gets a considerable part of this coal from West Virginia fields. These tidewater coal shipments from the Pennsylvania bituminous area amount to considerably less than the all-rail shipments to consumers in the east, but are slightly greater than lake-cargo shipments from Pennsylvania.

Tidewater shipments from Pennsylvania originate principally in the Central Pennsylvania and Somerset districts, though the other districts of the State contribute to this trade to a minor extent (Figure 23). West Virginia, chiefly through shipments to Hampton Roads, is a much more important figure in the tidewater trade than is Pennsylvania (Figure 26), and has been becoming progressively more important (Figure 27).

Destinations of all tidewater coal shipments from Atlantic ports for 1929 are shown in Figure 28, together with estimates of the destinations of Pennsylvania's tidewater shipments. According to the Pennsylvania estimates in the above figure, only a relatively small proportion of Pennsylvania's tidewater shipments of bituminous coal reaches New England. Instead, Hampton Roads, serving fields in southern West Virginia and southwestern Virginia, is the dominant source of the coastwise movement to New England. The dominance of bituminous coal from these southern fields over Pennsylvania bituminous coal in the New England trade is probably based upon the ability of the southern fields to furnish coal which is at least as good for domestic use as that from Central Pennsylvania, is satisfactory for industrial purposes, and is more than able to compete with Pennsylvania coal on a delivered price

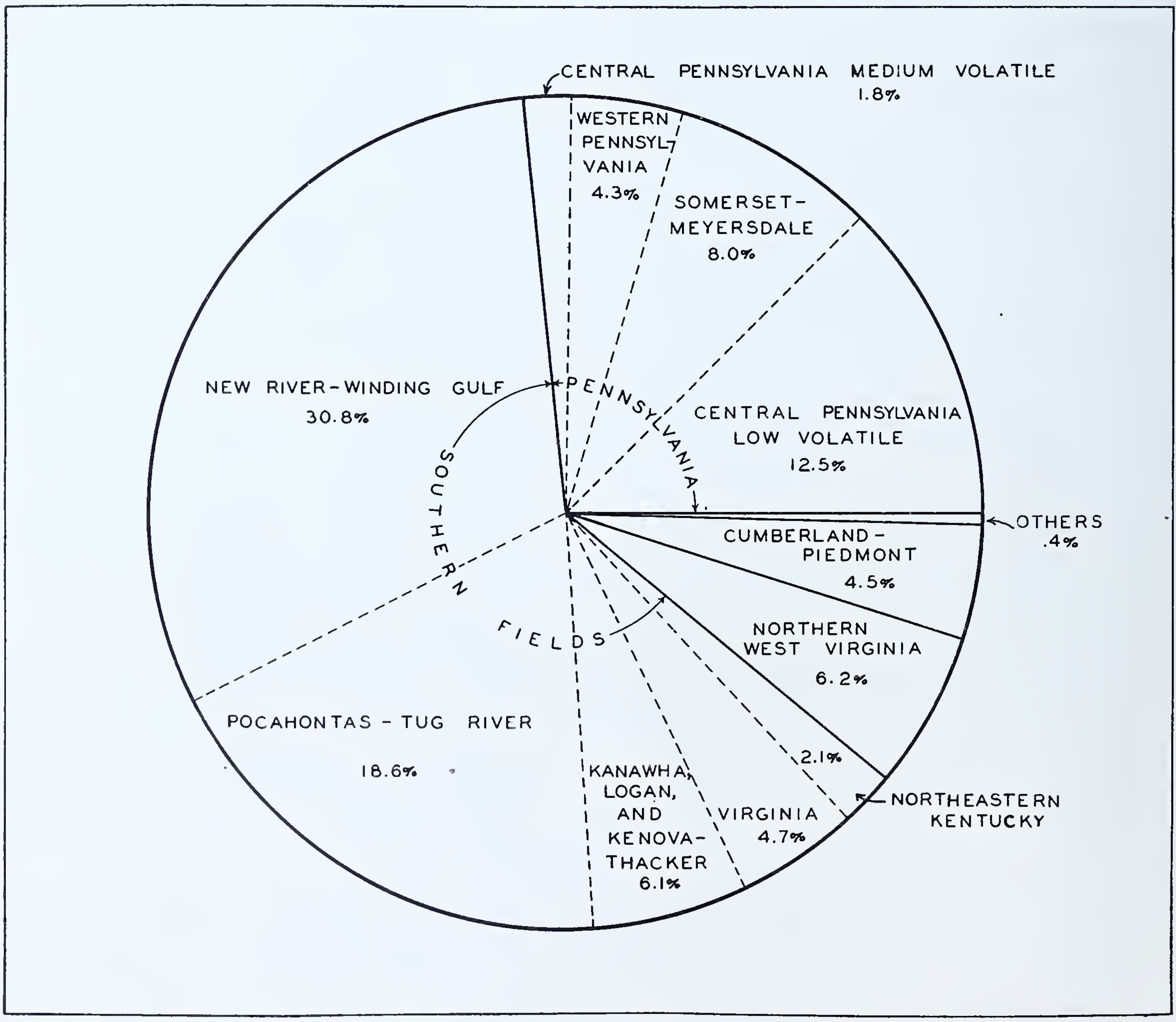

Fig. 26. Sources of tidewater bituminous coal, 1929. (Data from monthly coal distribution reports of United States Bureau of Mines.)

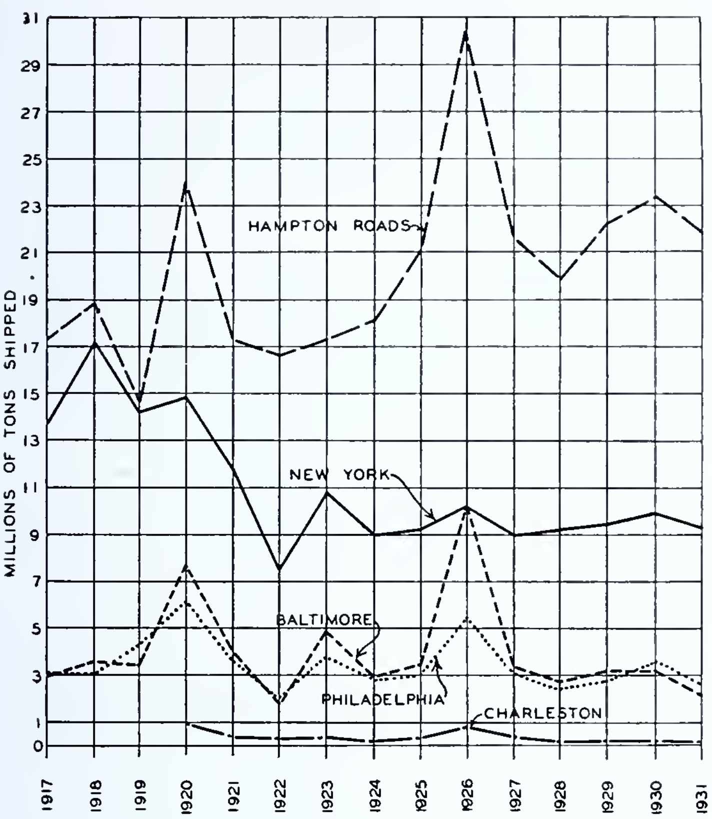

Fig. 27. Recent trends in tidewater bituminous coal shipments from each of the principal ports which engage in this business. (Data from Mineral Resources of the United States.)

basis. (For further details regarding the New England market see discussion in anthracite chapter.)

The fields which dump their coal at Hampton Roads also contribute more to the sea-borne export trade than does Pennsylvania (Figure 29). On the other hand, Pennsylvania ships more than her proportional share of bunker fuel, Central Pennsylvania coals being particularly well suited for this purpose. It is an unfortunate fact, however, that increased use of fuel oil by vessels has curtailed this market in recent years.

The item "inside capes" (Figure 28) refers to coal moved by barge to points within the capes at the entrances of Delaware and Chesapeake bays. The "other tonnage", which is a large proportion of Pennsylvania's tidewater shipments, refers chiefly to coal delivered at New York, consigned to the many large industrial plants equipped to receive coal by water in and around New York and northern New Jersey.

Export Trade. — The United States is not a large bituminous coal exporter, exports in 1931 amounting to only 12,126,000 net tons or about 3 per cent of the nation's total production. These exports are to Canada, to Mexico, and overseas. Exports to Mexico are very limited in quantity, so consideration may be centered upon exports to Canada and overseas, in both of which Pennsylvania participates to some extent.

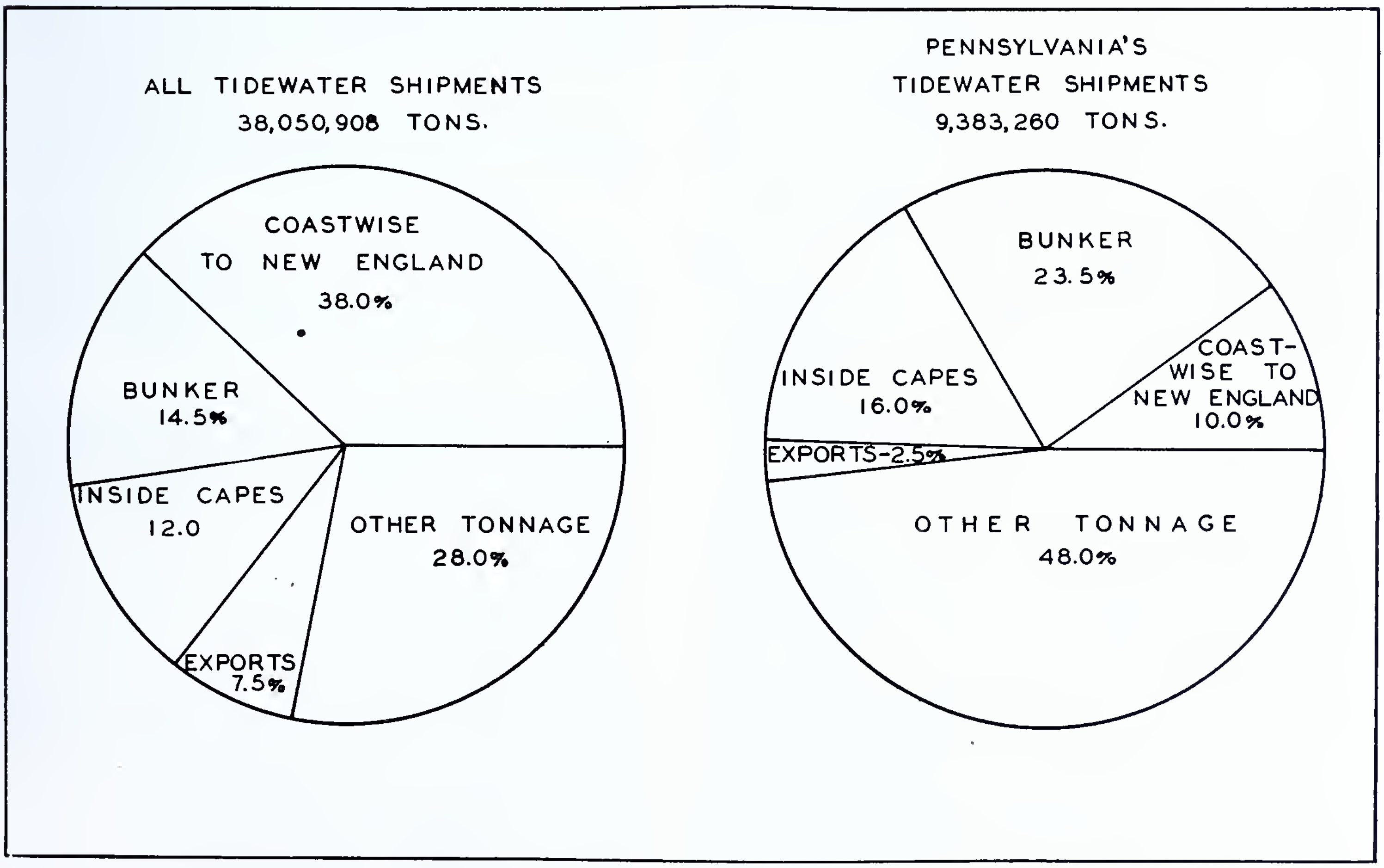

Fig. 28. Destinations of tidewater bituminous coal, 1929. (Destinations of all tidewater shipments are based on data in Mineral Resources of the United States; destinations of Pennsylvania's tidewater shipments are estimates based upon port summaries.)

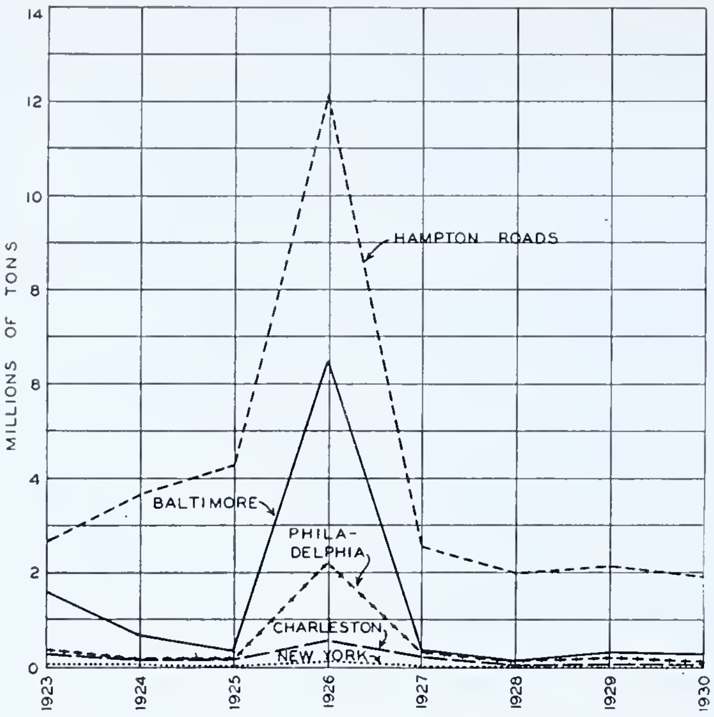

Fig. 29. Recent trends in sea-borne bituminous coal export trade from northern and middle Appalachian fields. (Data from Mineral Resources of the United States.)

Bituminous coal exported to Canada by the United States in 1931 amounted to a little more than 10,550,000 tons. Most of this coal was marketed on the shores of the upper Lakes, in peninsular Ontario, or in the St. Lawrence Valley. This section of Canada, stretching from Quebec to Winnipeg, is largely dependent upon imported coal, and has been called Canada's "acute fuel area". Coal from the United States reaches the "acute fuel area" of Canada either by lake-cargo movement or by all-rail haul, the amounts reaching Canada by the two methods being approximately equal. In the lake-cargo movement Pennsylvania participates to some extent; in the all-rail haul Pennsylvania plays an important part, since she is the nearest large coal producing state to the "acute fuel area". The writer estimates that in a normal year Pennsylvania sends, by the two methods combined, about 6,000,000 tons of bituminous coal to Canada.

The Canadian market for bituminous coal has held fairly steady for a number of years, and is likely to continue to do so. Canada has coal of her own in Alberta and Nova Scotia, but neither is near enough to supply the market of the "acute fuel area" in competition with coal from the United States. Although tariffs unfavorable to the United States and government subsidies to Canadian coal producers may result in the more extensive use of Canadian coals in this area, differences in the delivered costs of the Canadian and United States coals are too great to be overcome by legislation.

The other one and one-half million tons shipped from the United States in 1931 went, with the exception of the small amount exported to Mexico, to overseas points. Nearly all of this coal moves from Atlantic ports and is part of the tidewater coal. The demands of the overseas coal trade are exceedingly irregular. A British coal strike resulted, in 1926, in a large demand for bituminous coal both in Great Britain and in markets usually supplied by Great Britain; and in that year the sea-borne export trade of the United States exceeded by a considerable amount the exports to Canada. This was, however, unusual; and in 1931 the country's sea-borne export trade amounted to only about .4 of 1 per cent of our total production, or about one-seventh of our shipments to Canada for that year. Sea-borne export trade is, therefore, normally of only minor significance. Moreover, the fields which dump their coal at Hampton Roads obtain almost all of this export trade (See Figure 29), and it is estimated that not more than 200,000 tons of Pennsylvania bituminous coal were exported overseas in 1931.

The possibility of any large increase in the nation's export trade in bituminous coal seems remote. Since our imports are of relatively small bulk, coal exporting does not fit in with our system of trade. Great Britain, on the other hand, has usually had a large coal-exporting business, chiefly because she imports much bulky raw material and coal gives a good outbound cargo.

Summary By Pennsylvania Producing Districts

The uses to which the various Pennsylvania coals are put and the location of their markets are summarized by districts in the following paragraphs:

Western Pennsylvania.

Western Pennsylvania (Figures 22 and 30) produces about two-thirds of all the bituminous coal mined in Pennsylvania, the coal produced being dominantly high volatile.

Pittsburgh District. — For steam purposes, for coke manufacture, and for domestic use coals from the Pittsburgh district (a subdivision of Western Pennsylvania) enjoy a large market in the country about Pittsburgh. The most distinctive feature of the marketing of coal from this district is that most of the coal moves to nearby points in western Pennsylvania, in Ohio, and in western New York. The district leads all other Pennsylvania districts in lake-cargo trade and in

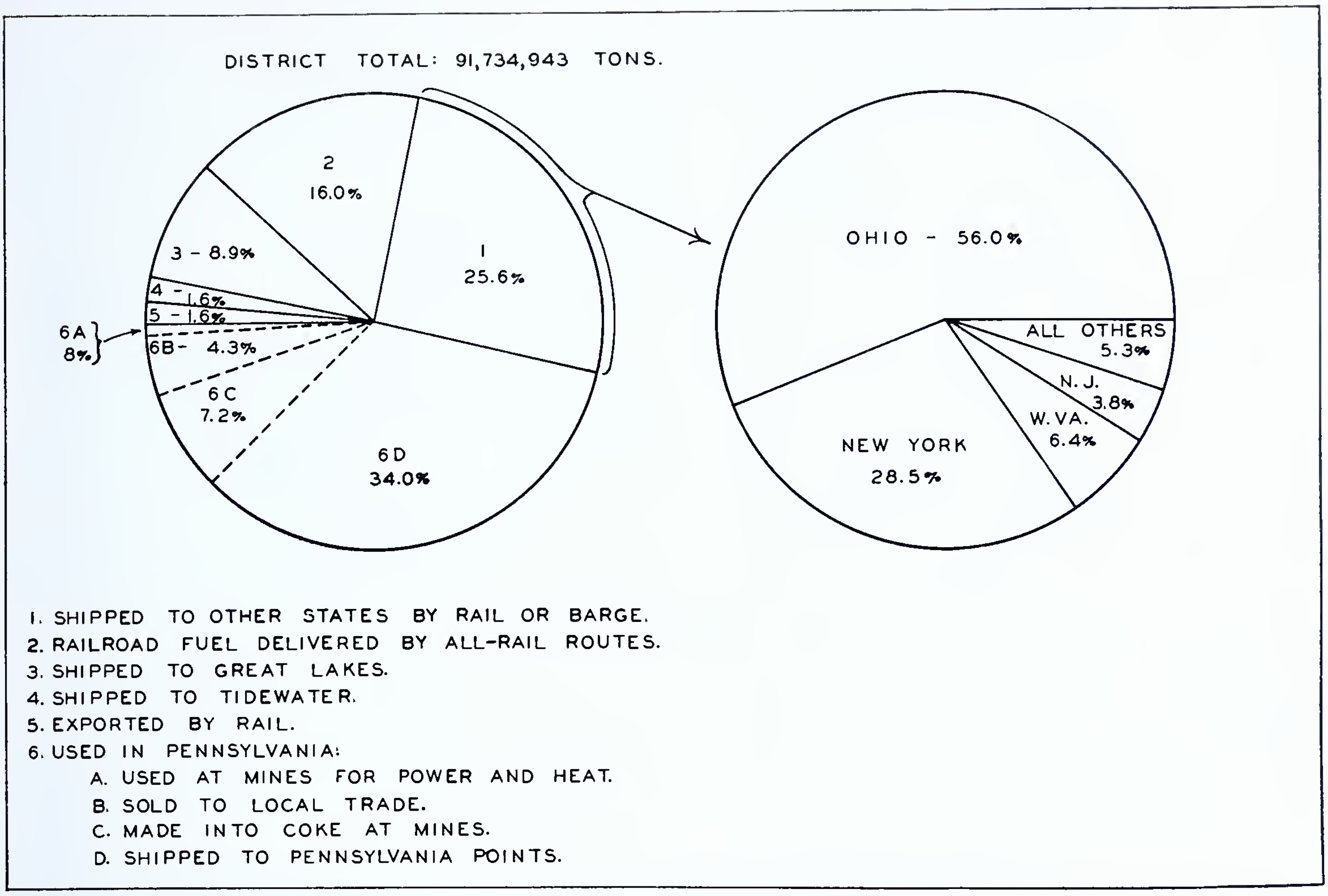

Fig. 30. Distribution of coal produced in Western Pennsylvania in 1929. (Data from monthly coal distribution reports of United States Bureau of Mines.)

rail shipments to Canada, while coal movements to tidewater and to inland points in the east are of some significance. The relatively low percentage of this coal used by railroads reflects its good quality for other uses and its location in an area where considerable coal is in demand for more exacting purposes.

Greensburg-Westmoreland, Latrobe, and Ligonier Districts.—The Greensburg-Westmoreland, Latrobe, and Ligonier districts constitute an important source of gas, by-product, and steam coal originating mainly on the Pennsylvania Railroad and its connections. Nearly half is used by industries within the State and about one-fourth by railroads.

Connellsville District.—The Connellsville district is the principal source of coking coal in the United States, exceeding all other districts in the production of this material. Although the beehive coke industry of the United States consumed only about one-eighth as much coal as the by-product industry in 1929, beehive coking still maintains a stand in the Connellsville district. A much larger tonnage of Connellsville coal, however, is used by by-product plants in western Pennsylvania.

The great value of the coal of the Connellsville district for coking purposes has formed the basis for the important iron and steel and affiliated industries of western Pennsylvania.

The Connellsville district sends coal to points in Pennsylvania outside the Connellsville district, sends some coal to Ohio for coking, contributes some railroad fuel, ships some lake-cargo coal, and even ships a little coal to New York, New Jersey, New England, and adjacent states, but the principal use of this coal is in coke making in western Pennsylvania.

Central Pennsylvania.

The coal produced in Central Pennsylvania (Figures 22, 31, and 32) ranges from high to low-volatile. The fields of this district are the principal source of supply for all-rail coal destined for industrial northeastern United States, the principal railroad fuel producers in the State, and important sources of bunker fuel loaded at New York and Philadelphia. In addition, some Central Pennsylvania coal is used in coke manufacture and a considerable amount in domestic heating. In the latter market the lower volatile coals have the advantage of very little smoke. As steam coal for railroad and industrial use, and

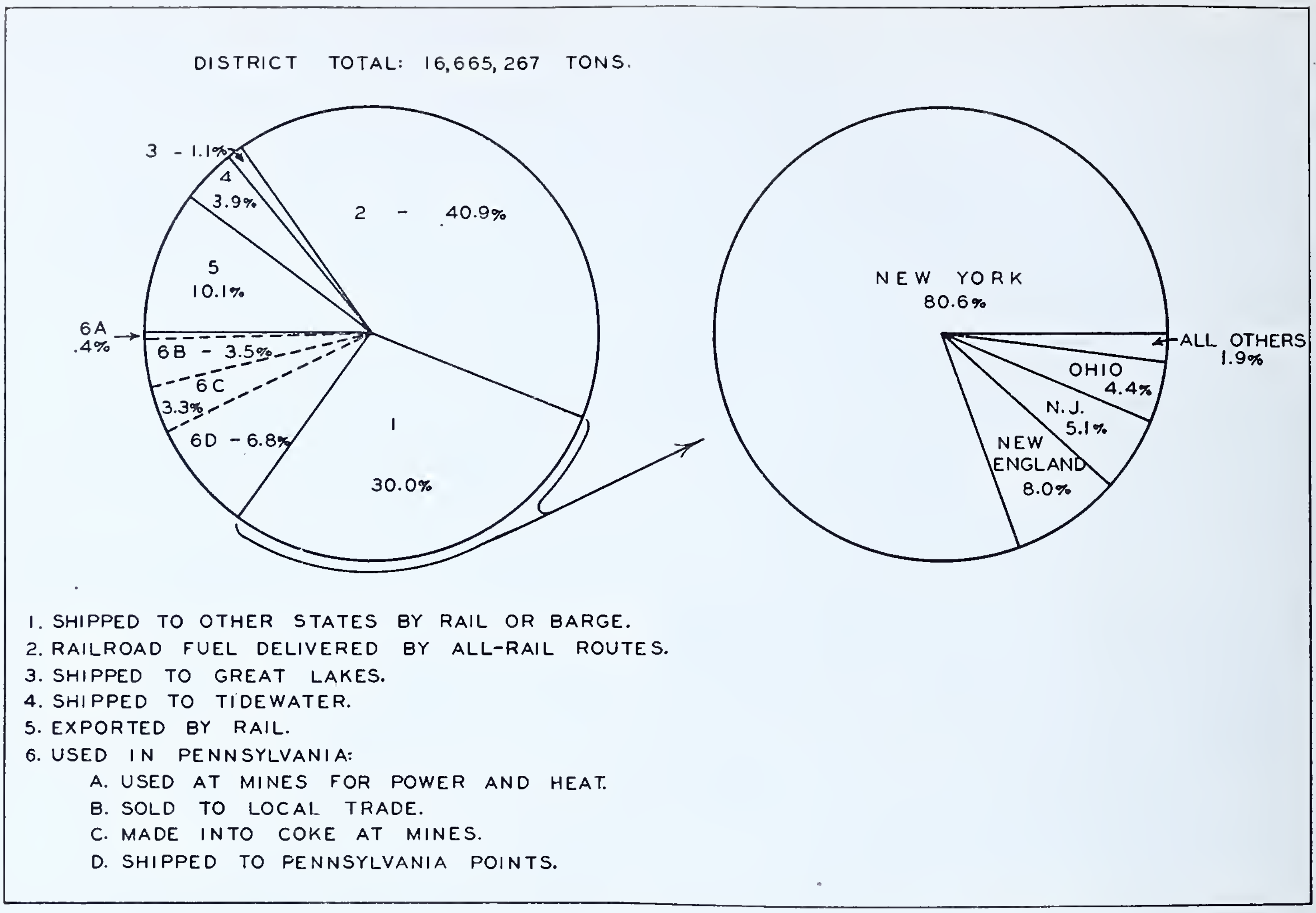

Fig. 31. Distribution of coal produced in the Central Pennsylvania medium-volatile district in 1929. (Data from monthly coal distribution reports of the United States Bureau of Mines.)

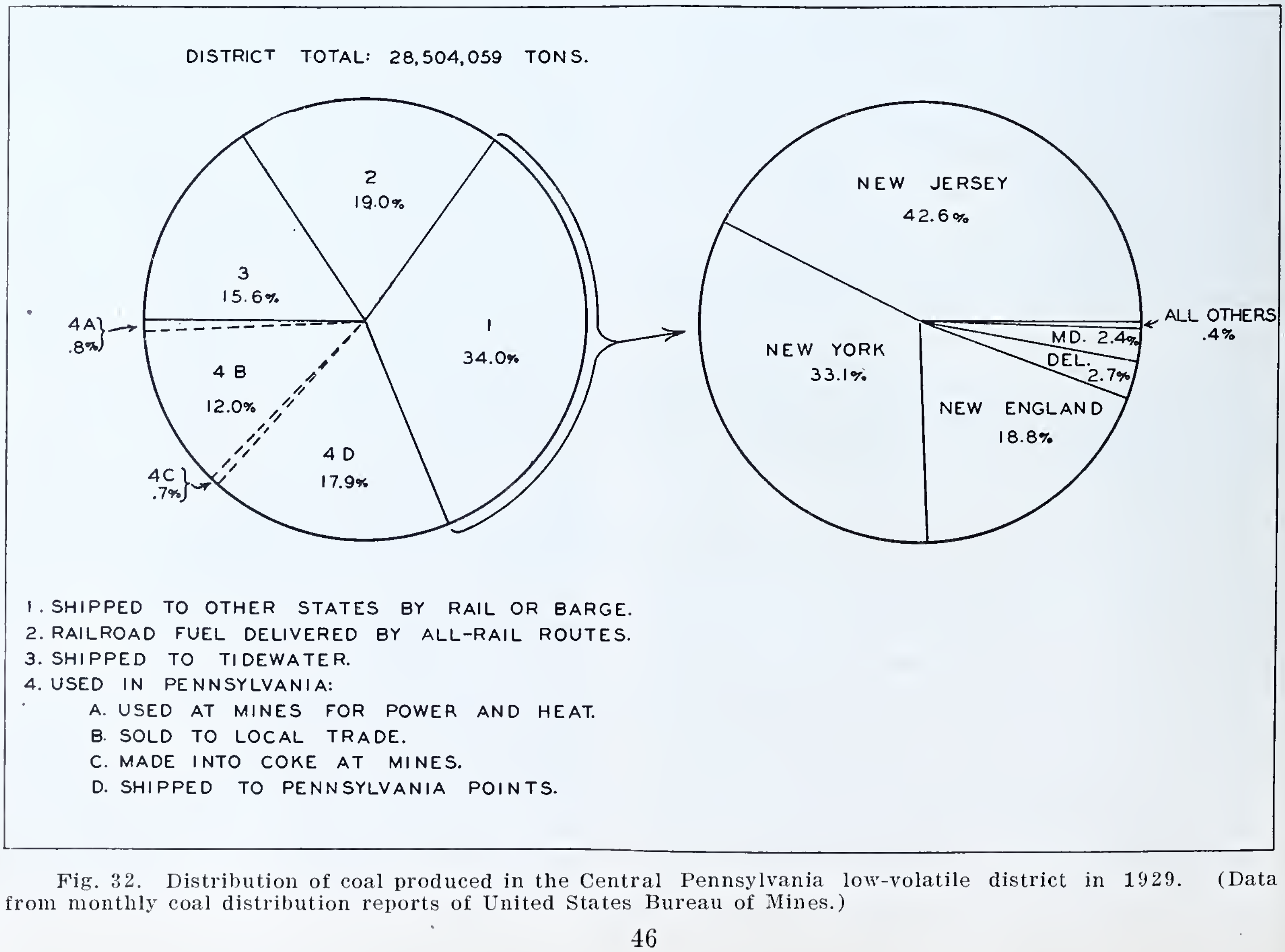

Fig. 32. Distribution of coal produced in the Central Pennsylvania low-volatile district in 1929. (Data from monthly coal distribution reports of United States Bureau of Mines.)

as bunker fuel Central Pennsylvania coals are outstanding.

The Central Pennsylvania field is frequently considered in two sections—the Central Pennsylvania medium-volatile field and the Central Pennsylvania low-volatile field. The latter is, of the two, much the more important source of bunker fuel. On the other hand, while both produce railroad fuel, the tonnage furnished by the medium-volatile field is greater (Figure 23), and the percentage of all bituminous coal from the medium-volatile district which is used for railroad fuel is more than twice as great as the corresponding percentage for the low-volatile district. The medium-volatile section, too, is much more important in Canadian shipments. The low-volatile district is more important in shipments to New Jersey and New England, while both regions send considerable tonnages to New York State.

Somerset-Meyersdale District.

The Somerset-Meyersdale district (Figures 22 and 33) produces low-volatile or "smokeless" coal. Although its outstanding disposal is as shipments to tidewater for bunker fuel, Pennsylvania, New Jersey, and New England receive a considerable percentage of this coal. Partly because the district produces "smithing" coal its shipments go to many states, covering a particularly wide area in proportion to the district's production.

Competitive Position of Bituminous Coal

A number of references have already been made to the competition which bituminous coal has had to face within recent years. Domestic and imported oil, natural gas, and water power have been the most serious competitors. Trends in the relative importance of these various sources of energy are brought out in Figure 21. Bituminous coal supplied 70 per cent of the total annual energy derived from mineral fuels and water power in the United States in 1909; in 1929 the share of bituminous coal had fallen to 53 per cent, and in 1931 to about 48½ per cent.

Tariffs

Although bituminous coal has suffered chiefly from domestic competitors, efforts have been made to lessen that part of the competition resulting from importation of fuels. To this end tariffs on foreign coal and on oil were imposed in 1932. The tariff on crude oil is discussed in the chapter

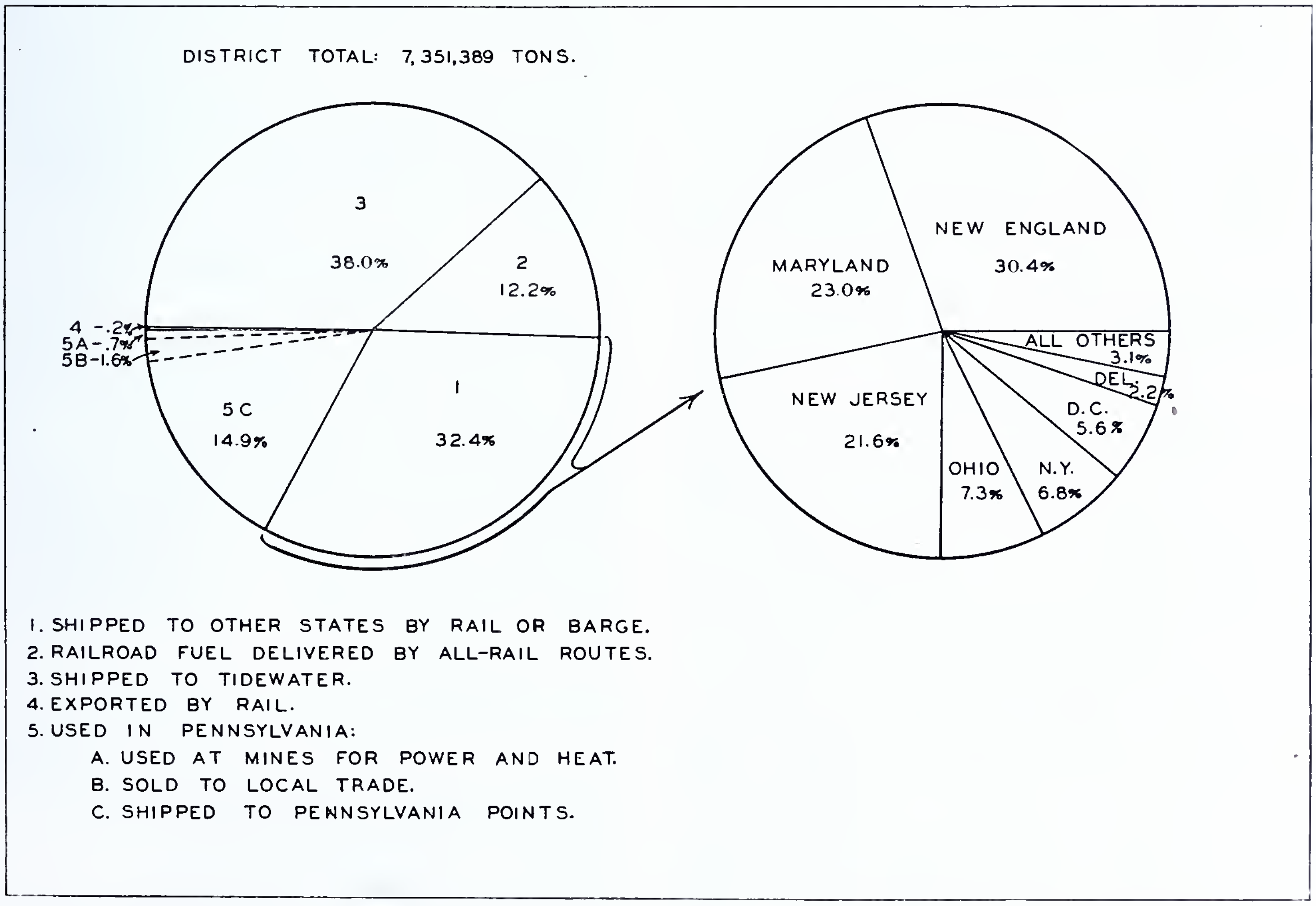

Fig. 33. Distribution of coal produced in the Somerset-Meyersdale district in 1929. (Data from monthly coal distribution reports of United States Bureau of Mines.)

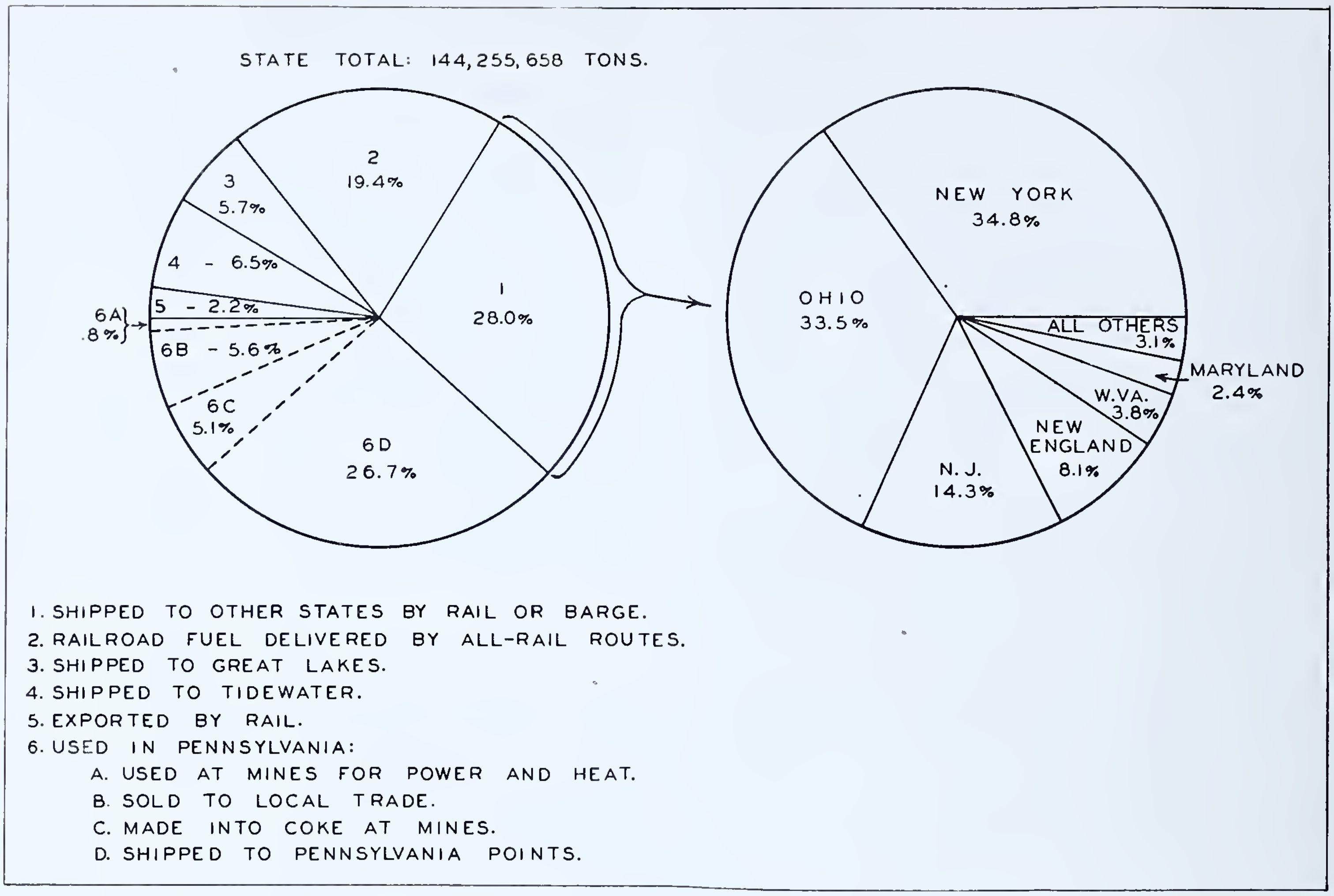

Fig. 34. Distribution of all coal produced in Pennsylvania in 1929. (Data from monthly coal distribution reports of United States Bureau of Mines.)

on petroleum. The tax on foreign coal was "10 cents per 100 lbs. on coal, coke, and briquets." It applied only to shipments from countries which, in 1931, exported more coal to the United States than they received from this country.

Seasonal Character of Bituminous Coal Consumption

Few people appreciate fully the seasonal character of bituminous coal consumption. The most extreme seasonal fluctuation is shown by domestic consumption, which takes twenty or thirty times as much bituminous coal in the winter as in the summer; but most of the other uses of coal show a similar fluctuation though in a lesser degree. Railroads, electric utilities, city gas plants—all have a similar consumption curve, the coal used in December or January being perhaps 20 per cent greater than that consumed in July. Even the consumption by general manufacturing industries is greater in winter than in summer, because of the large amount of fuel required to heat factory buildings. The only one of the major coal users not showing a marked midwinter peak in its consumption curve is the coke industry, which uses most coal in spring and fall, with a depression in midsummer and lowest consumption in midwinter.

Storage of Coal

Seasonal operation of mines is an uneconomical procedure and leads to high costs which are passed on to the consumer, and the only cure for seasonal demand is storage—by the producer, by the consumer, or by some intermediate agency. The producer rarely has facilities for storage, so it is left largely to the consumer or to wholesalers or retailers. For instance, householders are encouraged to get in their winter coal supply during the summer months, and some of the winter burden is shifted in this manner. Another example is storage of large quantities of lake-cargo coal each summer along the Great Lakes for distribution throughout the Northwest. Many large industrial consumers such as utilities have facilities for storing coal, and nearly all retail and wholesale bituminous coal dealers store coal to some extent.

The storage of coal for the slack season is desirable from several points of view. It keeps the miner at work, it insures the consumer of a supply of coal when he needs it, and it spreads the burden of transportation over a longer period. Danger of spontaneous combustion, loss from weathering, increased breakage, the expense of handling, the cost of storage space—all operate against storage, but it remains an economic necessity to the industry. To encourage storage, special summer cost reductions are made in the anthracite region. Though higher winter prices often result from winter congestion in the bituminous coal industry, the deliberate adoption of special low summer prices has not been thoroughly tried out. Most operators could well afford to reduce prices during the summer season if by so doing they could operate their mines more regularly with the economies which steady operation brings. Some general system of price reduction for bituminous coal delivered in the summer should be adopted. To the same end it has been recommended that the railroads be allowed to grant a differential freight rate for coal hauled during the spring and summer months.

The Selling of Coal

As in the case of anthracite, the major item in the consumer cost of bituminous coal is labor; but, as explained in the anthracite chapter, the labor cost per ton is several times as great in anthracite mining. Naturally, too, the labor costs are usually higher in the unionized bituminous coal fields than in the non-union fields.

In distributing bituminous coal to the consumers several methods are possible. Some coal goes directly from the mines to the consumers, but this is possible only with large industrial users of coal. More commonly the mine sells to the wholesaler or ships to the Lake docks; the wholesaler, without physically handling the coal, sells it to large industrial consumers, to retailers, or to others who buy carload lots; the retailer purchases his supply from the mine, the wholesaler, or the docks, and it is from the retailer that most small consumers buy their coal. The United States Coal Commission in its report published in 1925 concluded that there were too many wholesalers and too many retailers, that reduction in their numbers accompanied by a more thorough use of existing facilities for distribution would effect a saving to the consumer.

Transportation Or Getting Coal To Market

In dealing with a product as bulky as bituminous coal the problem of transportation is a serious one.

Methods

Figure 19 suggests something of the physical means by which Pennsylvania's coal reaches its consumers. For the purposes of the present discussion, coal "used at mines for power and heat" and that "made into coke at mines" need not be considered, since they present no transportation problems. Coal "loaded at mines for shipment" and coal "sold to local trade and used by employees" requires some means of transportation to consumers.

Bituminous coal loaded at mines for shipment amounted to 92 per cent of Pennsylvania's total production in 1931. Of the coal loaded for shipment 82 per cent (as estimated from 1929 data) originated on railroads, that is, was loaded for shipment by railroads. This coal was for railroad fuel for the originating and other lines, for all-rail delivery to non-railroad consumers in Pennsylvania and outside of Pennsylvania, for all-rail shipment to Lake Erie there to be loaded into lake steamers, and for rail shipment to tidewater. Since in addition to the large amount of coal loaded for shipment on railroads some of the coal "sold to local trade and used by employees" is delivered directly to tenders of steam locomotives at tipples, it is apparent that the railroads are of primary importance to the bituminous coal industry both as consumers of coal and as transporters of coal to other consumers. For this reason it is often said that "the coal problem is a railroad problem." Forty-two and one-half per cent of the coal loaded by railroads in Pennsylvania in 1930 originated on the Pennsylvania Railroad, and about 10 per cent on the Baltimore and Ohio, while a number of other railroads transported the remaining 47½ per cent.

Seventeen and one-half per cent of the coal loaded for shipment in Pennsylvania in 1930 was loaded directly upon river barges or other river vessels, in some instances to be later shipped by railroad from down-river points. The figure thus represents bituminous coal originating as river shipments. Of the 19,820,506 tons which this 17½ per cent represents, 19,022,849 tons were loaded on the Monongahela River whose location with respect to areas of coal production gives it great significance in this trade. The Allegheny River originated 797,657 tons. It is interesting to note that 90 per cent of the coal originating on waterways in the United States in 1930 was loaded for shipment on the Monongahela.

Bituminous coal "sold to local trade and used by employees" in Pennsylvania amounted to 5.9

per cent of the State's total production in 1931. The part of this which is sold to company employees is usually hauled by truck or wagon to the individual coal bins. Longer truck hauls carry coal to other domestic users in nearby towns and villages. Other local sales are to industrial users such as brick and tile works adjacent to the mines, and some coal is delivered directly to tenders of steam locomotives at the tipples. Since some coal is delivered by truck and wagon haul, highways must be considered with railroads and waterways as coal carriers, but the amount thus carried is not very significant.

The use of high-pressure pipe lines for transporting pulverized coal from the mines to consuming centers is being considered at the present time.

Freight Rates

The freight rate structure as it affects bituminous coal is exceedingly complicated[7]. In fixing freight rates, the work of the Interstate Commerce Commission, it has always been the theory that competition is desirable, and that expansion of coal production is needed.

Preferential rates have been given to newer and outlying fields with the inevitable consequences of stimulating further over-development, spreading the market of each field over a larger geographical territory, making the consumer of "short-haul" coal bear part of the cost of transporting the "long-haul" coal, and making the average freight rate on all coal higher than it need be by favoring the "long-haul" coal, and thus enabling it to come to the market in larger proportion than would otherwise be possible. The crying need of the present is a thorough revision and simplification of freight rates, so that they will be based primarily upon actual cost of service.

The question of a differential on southern coal shipped to Lake Erie, a freight problem of special interest to Pennsylvania, has already been discussed. It is typical of the difficulties brought about by the theory of rate fixing which has prevailed.

Taxation

Taxation of coal reserves has been the subject of much criticism. Under our present system, owners of coal lands pay taxes on these lands (as coal properties) for possibly a century, while they may be getting no income from the coal. This obviously encourages development and over-production. A deferred tax plan has been suggested whereby only a tax on surface valuation is paid until the coal is actually produced, and then the deferred coal taxes are collected. In 1931 a Commission was created by the State Legislature for the purpose of investigating the subject of taxation of forest and mineral lands in the State, and it is hoped that some better system of taxing coal lands than the present one will be devised.

The Plight of Bituminous Coal

The bituminous coal industry has for some years been suffering acutely from overproduction. As already explained, the Interstate Commerce Commission long acted under the assumption that maximum competition was good for the industry. This attitude on the part of the Commission, the prevalent system of car allotment in times of car shortage, the occurrence of strikes in the unionized fields with resultant stimulation of small unorganized mines, increasing mechanization making more rapid production possible—these and various other causes have brought the industry to its present sorry plight. While productive capacity has increased, competition from other fuels and increasing efficiency of coal utilization have curtailed coal demand.

No attempt will be made here to discuss the numerous suggestions which have been advanced for rehabilitation of the bituminous coal industry. It has long been the belief of many that some form of pooling or consolidation of coal properties would best overcome the present inefficient overproduction. For a long time attempted combinations of this sort met with serious opposition on the grounds that they were violations of the Sherman anti-trust law. At last in March, 1933, the Supreme Court of the United States rendered a decision in the case of Appalachian Coals, Inc., which opens the way to the much needed consolidation.

More than a year previous to the date of rendering of the Supreme Court decision, Appalachian Coals, Inc., was formed. It consisted of 137 producers in the Southern high-volatile district of Kentucky, Tennessee, and the Virginias, and represented three-fourths of the tonnage of this district. A trial court, though in sympathy with the efforts of the operators, found the corporation an infringement of the Sherman anti-trust law.

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[7] The reader is referred to Soft Coal Bulletin No. 2, "Freight Rates on Bituminous Coal," published by The Greater Pennsylvania Council. This publication presents a clear and concise picture of the complete freight rate situation, covering soft coal.

This decision was reversed by the recent Supreme Court action.

What effect on the coal industry will this liberalization of the Sherman anti-trust law have? Other similar agencies, representing other groups of operators, are already forming in Pennsylvania and elsewhere. The movement will undoubtedly bring about some control of production and hence a beneficial stabilization of the industry. Moreover, producers of a certain rank of coal will now present a unified front in marketing their product. A healthier industry seems certain to result.

The Future of The Bituminous Coal Industry In Pennsylvania

The future of the bituminous coal industry in Pennsylvania is, of course, closely related to that of the country as a whole. The Pennsylvania fields have, in fact, suffered more from the general overproduction than the southern West Virginia and Kentucky fields; since the latter, because of lower wage scales, more favorable freight rates, and certain other advantages, have been able to make relative gains in the northern markets. Pennsylvania is particularly eager, therefore, for an early solution of the overproduction problem.

Future Shifts In The Industry

A glance at Figure 16 will show that the greatest coal reserves lie in Greene and Washington counties. A shift of the principal mining activity of the State to these southwestern counties is to be expected.

Conservation

Although there is estimated to be over 40,000,000,000 tons of recoverable bituminous coal left in the ground in Pennsylvania, less than 10 billion tons are in thick or moderately thick beds such as those now being mined. At the present rate of production this will last 70 or 75 years. At the end of that time large reserves will still remain, but of coal occurring in such thin seams and so difficult to mine that the State will be unable to maintain its position as a leading producer. Since the great metallurgical and other manufacturing industries of the State depend upon cheap coal, it is obviously highly important that coal waste be eliminated.

The Future of Coal Mining Communities

A problem which arises occasionally even now and which is sure to arise more frequently in the future is this: As the minable coal is exhausted, what will become of the mining communities? Will the present coal-mining valleys revert to wilderness? It has been suggested that the housing, labor supply, and other facilities might well attract new industries—that the mining communities might thus gradually change to manufacturing towns. These communities should be carefully studied, and, eventually, assisted in readjusting themselves to their changed environment.

V

COAL PROCESSING

The smoke and soot which result from the burning of bituminous coal have been the cause of many complaints. Not only do they villify the air which we breathe, but they represent, also, a serious waste of gases (volatile matter) contained in the coal. Several things can be done about it. The coal may be heated in retorts, thereby driving the volatile matter off and leaving a light, porous, smokeless fuel called coke. If this process is carried on in a special kind of oven, called a by-product oven, tar, gas, and various other products are obtained in addition to coke. Or, the bituminous coal may be treated particularly for its gases, with coke as a secondary product. These and similar processes are referred to as "coal processing".

The principal methods of coal processing are discussed in the following pages under four heads: high-temperature carbonization, the manufactured gas industry, low-temperature carbonization, and liquefaction.

High-Temperature Carbonization

High-temperature carbonization is carried on at temperatures of about 1650 to 2200 degrees Fahrenheit. This method of treating raw coal is at present by far the most important of the three types mentioned, since it results in nearly all the coke, and, directly or indirectly, most of the manufactured gas which is now consumed.

The Coke Industry

When certain kinds of bituminous coal are heated in retorts out of contact with air the volatile matter is driven out leaving the fixed carbon and ash of the coal in a porous mass known as coke. A somewhat similar material is left as a residue when crude oil is refined.

The major interest of the coke industry is in obtaining a product strong enough to be suitable for blast furnace and foundry use. Coke made in by-product and beehive ovens supplies nearly all of this demand. Coal-tar coke, though suitable for metallurgical use, is produced in such limited quantities as to be of small importance. The only other coke produced by high-temperature carbonization, gas-house coke, is too soft for metallurgical purposes.

The United States Census gives the total value of coke and by-products resulting from the coke industry in Pennsylvania in 1929 as $115,345,477 of which $38,622,904 represents value added by manufacture, the remainder being the value of raw materials and fuels used.[1] Five thousand persons were employed by the industry in the State in 1930.

Beehive Coke.

Pennsylvania is the mother state of the country's coke industry. It was in Fayette County, Pennsylvania, in 1817, that the first coke was made in the United States. This first coke was made on the ground in mounds, similar to the burning of charcoal. The first use of coke ovens was in Fayette County in 1841, but coke making on a large scale did not begin until 1859 at which time 30 ovens were built at the Fayette Coke

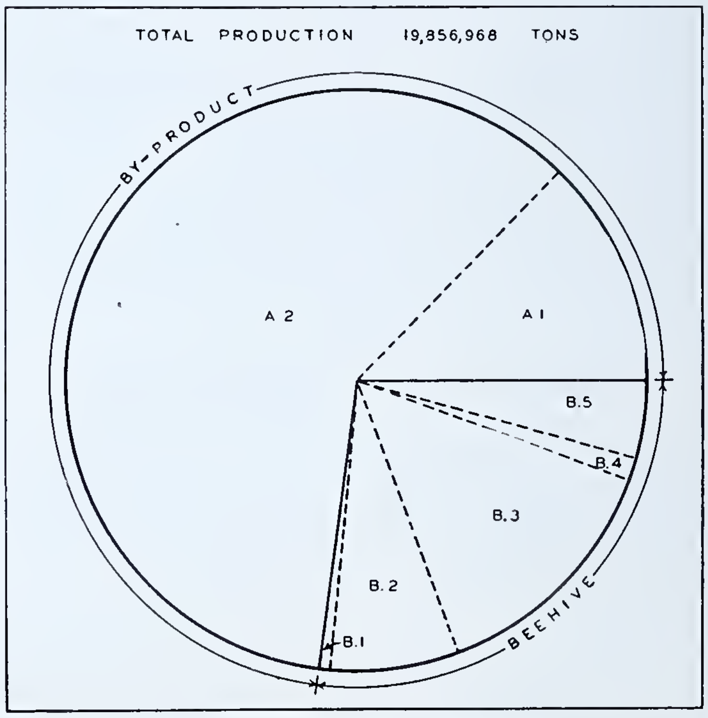

Fig. 35. Production of coke in Pennsylvania in 1929 by districts. (Data from Mineral Resources of the United States.)

A. By-product (73% of total coke)
1. Eastern Pennsylvania (includes plants in Bethlehem, Chester, Lebanon, Philadelphia, Steelton, and Swedeland) 12.7%
2. Western Pennsylvania (includes plants in Alliquippa, Clarion, Erie, Johnstown, Midland, Neville Island and Pittsburgh) 60.3

B. Beehive (27% of total coke)
1. Allegheny Mountain and Allegheny Valley 6
2. Connellsville 7.2
3. Lower Connellsville 13.6
4. Upper Connellsville 1.3
5. Pittsburgh and other districts (including the very small amount of beehive coke produced in Ohio) 4.3

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[1] These figures do not include the products of by-product coke ovens operated by gas utility companies, since the Census considers these part of the manufactured gas industry.

Works. From then on coke manufacture increased by leaps and bounds, and in this rapid rise the beehive oven reigned supreme until about 1918.

Location of an important beehive coke industry in Pennsylvania was dependent primarily upon the presence of good coking coal. Most coals of bituminous or semi-bituminous rank will coke, but the product of some seams is far superior to that of others. Thus, the Pittsburgh seam of southwestern Pennsylvania was found to make a superior coke in beehive ovens, and the coking industry which grew up in the Connellsville district based principally upon this Pittsburgh seam made Connellsville coke a standard by which other cokes were judged. A number of other coals occurring in the State were used for beehive coking, but the Pittsburgh seam of the Connellsville district over-shadowed all others.

The question of what constitutes the best possible coking coal has been much discussed. Most coals of the Appalachian region containing from 17 to 37 per cent of volatile matter may be made to yield a satisfactory coke in beehive ovens; but the best adapted coals seem to be those in which the volatile matter is about 32 per cent, ash about 7 per cent, sulphur less than 1½ per cent, and phosphorous less than .02 per cent. Still, no hard and fast rule can be laid down, and a coal which seems satisfactory according to all known criteria may simply not make good coke.

Although now considered wasteful, since it permits no recovery of by-products, the beehive process should not be judged too harshly as it was well adapted to its place and time. The capital investment per oven was small, and little time was required for construction. Each oven was a unit in itself, and coke could be made on any scale, large or small. The completed oven was easy to start and easy to shut down, and since the ovens were of necessity located near good coal supplies the operator could shut down some of his ovens and ship raw coal when the demand for coke was bad. All of these factors combined to make the overhead charges in beehive operation small, and to adapt the industry to the conditions which existed during what might be called the pioneer stages of the country's industrial development.

Disadvantages of the beehive oven were its exacting coal requirements and the fact that byproducts were wasted. According to 1931 averages of the United States Bureau of Mines, a ton of bituminous coal coked in a beehive oven will yield about 1300 pounds of metallurgical coke

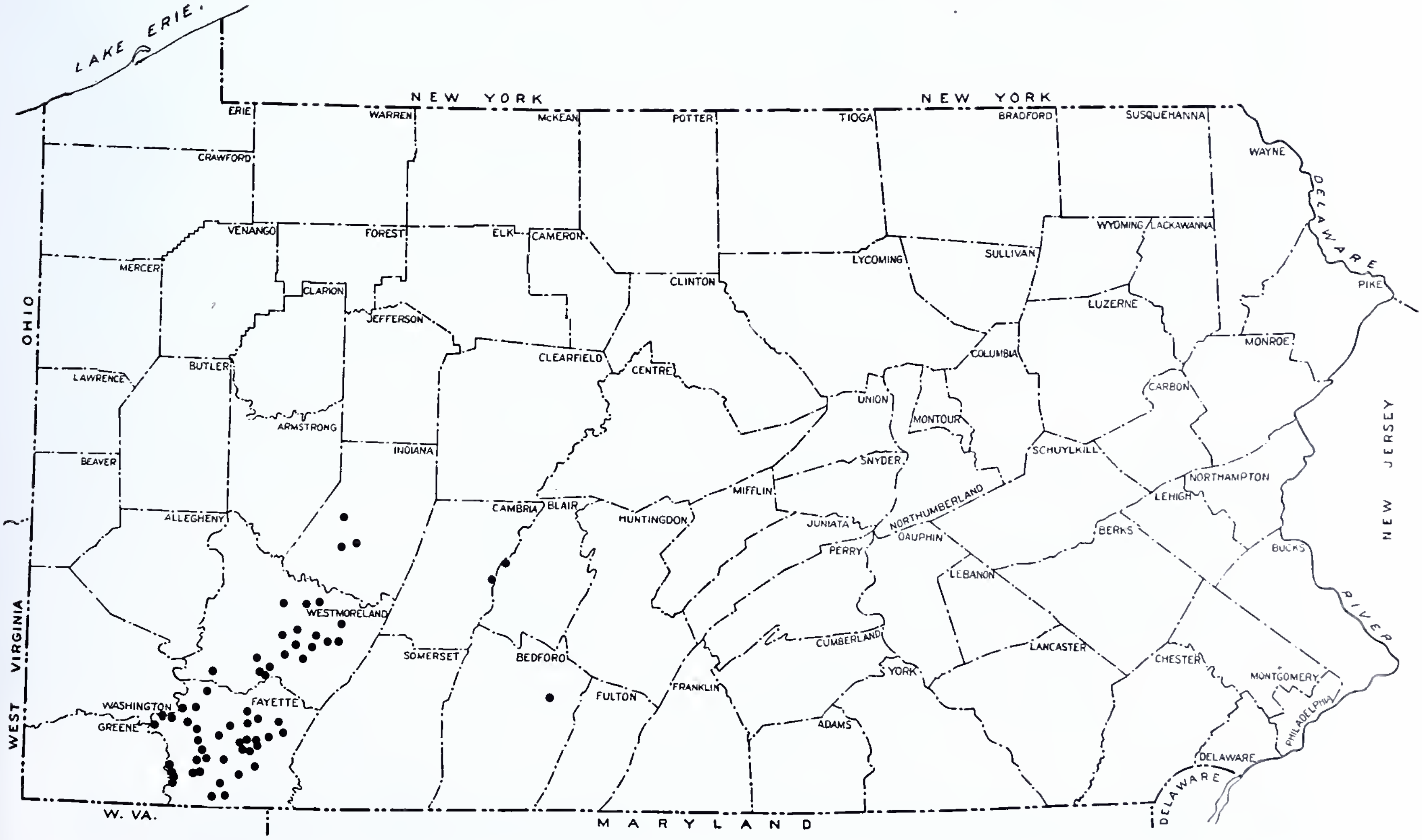

Fig. 36. Beehive coke plants in Pennsylvania in 1930. (Data from Seventh Industrial Directory of Pennsylvania.)

and 80 pounds of breeze; coked in a by-product oven the same amount of bituminous coal will yield about 1380 pounds of coke of equally good quality and 130 pounds of breeze; together with about 24 pounds of ammonium sulphate, 9½ gallons of tar, 3 gallons of light motor oil, and 11,000 cubic feet of gas. Thus, not only does the by-product process produce more coke per ton of coal used, but it also produces by-products which almost equal the coke in total value. Such facts make clear the wastefulness of beehive coking as compared with the by-product process. On the other hand, the marketing of some of the by-products presents a growing problem.

Pennsylvania accounted for three-fourths of the beehive coke manufactured in the United States in 1931, the remainder being made in West Virginia, Virginia, Colorado, and several less important states. Nearly all of the Pennsylvania production came from the Connellsville district of Fayette and Westmoreland counties (Figures 35 and 36).

Most beehive coke is manufactured by coal operators at the place of coal production, and then sold as coke to the consumer (Figure 37). In this respect the industry differs markedly from by-product coking which is, in most cases, carried on in or near the area of consumption and frequently by the consumer.

The use of coke, both beehive and by-product, will be discussed later in this chapter under a separate heading. Coke breeze (screenings too fine for metallurgical or household use) results from both coking processes. Its disposal is discussed with that of coke.

The Shift to By-product Coking.

A growth in knowledge regarding the recovery and use of by-products from coal and the growing value of these by-products have been the principal factors in the rapid displacement of the beehive process by by-product coking, a displacement which was hastened by the War-time demand for explosives.

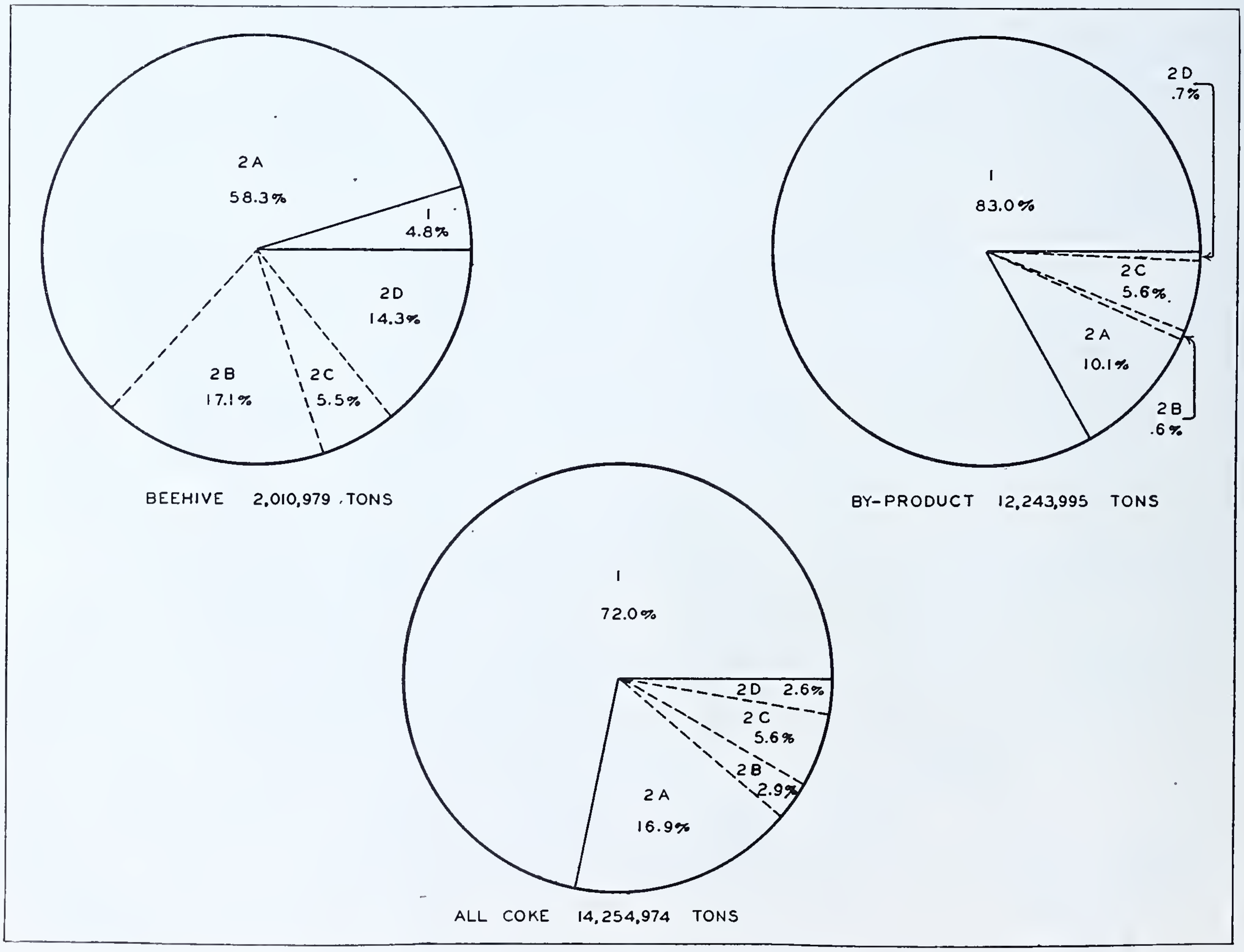

Fig. 37. By-product and beehive coke sold or used by producer in Pennsylvania in 1930. (Data from Mineral Resources of the United States.) (1) Used by producer in blast furnaces, etc.; (2) Sold by producer (A) for furnace use, (B) for foundry use, (C) for domestic use; (D) for industrial and other use.

In 1919 by-product coke production in the United States exceeded the production from beehive ovens for the first time, and by-product coke has led ever since, growing in relative importance until it amounted in 1931 to about 96.5 per cent of the total. In this change Pennsylvania has lagged behind, only 90 per cent of her coke being made in by-product ovens in 1931 (Figure 38).

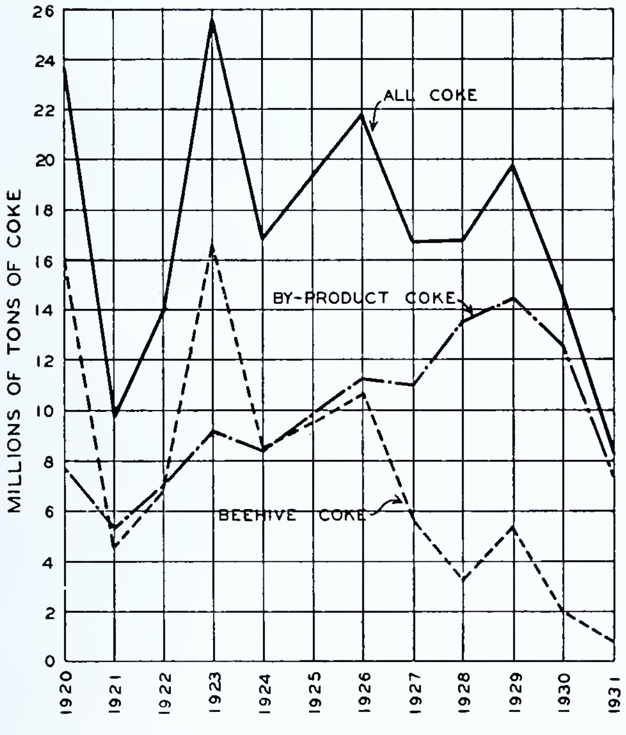

Fig. 38. Production of beehive coke, by-product coke, and all coke in Pennsylvania, 1920 to 1931. (Data from Mineral Resources of the United States.)

The beehive oven gave way to by-product coking in Europe years ago, the relative slowness of this change in the United States being accounted for in several ways. During the early days of by-product coking in the United States there was always a question as to whether by-product coke was as good as beehive coke, and this delayed the change somewhat. Even with the fact established that the by-product coke is as good as the older product, there were several reasons for the change being slow. One of these was conservatism in making new investments. A by-product plant requires such a large investment that steady operation over a long period of time is a prime necessity. The demand for many of the by-products has been small in the United States. For example, lack of a dyestuffs industry has meant a small demand for benzol products and low prices for tar. Another deterring factor was the absence of a market for by-product gas near Pittsburgh, the great iron and steel center, where coke was most in demand. Natural gas was available there and competed with coke-oven gas, the principal by-product of the by-product coke industry. Violent fluctuations in the production of iron and steel and consequently in coke demand were more marked in the United States than in Europe, and could be better faced by the beehive industry than by the by-product plants, since continuous operation is so essential to the latter. A sparser population in the United States than in Europe has operated to limit the market for by-products, and hence to discourage the change to the by-product coking process. Last, but not least, the United States has always been so well supplied with fuel that it has seemed unnecessary to use coal as efficiently as in many other countries. When it is remembered that only 4.5 per cent of the coke made in the United States in 1931 came from beehive ovens, it is clear that the adverse conditions outlined above, while retarding the shift to by-product coking, did not prevent this shift.

There are various reasons for Pennsylvania lagging behind the United States in the change. The iron and steel industry of Pennsylvania, located principally in the western part of the State, requires a large amount of coke, but furnishes few markets for by-products. Coke-oven gas, the outstanding by-product, has had to face competiiton with natural gas which is a superior fuel. With coal near at hand and a large number of beehive ovens long established it is not surprising that this section remains today the main stronghold of beehive coking in the United States, though even here by-product coking is now much more important.

There has been a growing tendency for the beehive coke manufactured to assume the character of an auxiliary supply to satisfy the peak requirements of the metallurgical industry in times of active business, and the peak demands of the domestic heating market. Some of the beehive ovens of western Pennsylvania, however, remain fairly steady producers.

By-product Coke.

The by-product coke industry is characterized, as its name implies, by the saving of by-products. The plant is elaborate as compared with those of the beehive industry, requires a large outlay of capital, and has large operating costs. With its intricately designed retorts, its apparatus for by-product recovery, and its tar and benzol stills it is essentially a chemical factory.

Coal Requirements.—In addition to the saving of by-products it will be remembered that the by-product process has the advantage of less exacting coal requirements than the beehive industry. This is chiefly because operators of by-product ovens can prepare a ''charge'' of desired composition by mixing suitable proportions of two or more coals of unlike character.[2] Pennsylvania was well supplied with beehive coking coal, and the change to by-product coking has simply extended the State's area of coking coal production.

The character of the product and hence the character of the coal used in by-product coking depends in considerable part on what is desired. If the plant is located near a city, the stress may be on production of gas, and the coal selected may be one of especially high gas content. On the other hand, by-product plants located close to steel mills place the greatest stress on the quality of the coke produced and not on the by-products. However, all coke-making processes now known require coals of medium-bituminous to semi-bituminous rank and of low sulphur content.

Production of By-Product Coking Coal In Pennsylvania. — About 43 per cent of the coal used in by-product ovens in the United States in 1929 came from Pennsylvania. Of the Pennsylvania coal which was used in by-product ovens about 60 per cent came from the Connellsville district, about 20 per cent from the Pittsburgh district, and nearly all of the remainder came from the Central Pennsylvania and Freeport districts.

About 57 per cent of this coal (originating in the State) was coked in Pennsylvania, 20 per cent in Ohio, 11 per cent in New York, and the remainder in West Virginia, Maryland, Indiana, Massachusetts, Minnesota, and several other states. Pennsylvania produced 25 per cent of the United States total of by-product coke in 1931, twice as much as Ohio, its nearest competitor.

Types of By-Product Plants. — Coke-oven plants are commonly differentiated into two types, ''furnace'' and ''non-furnace.'' A ''furnace'' plant is one that has for its main business the production of furnace coke (for blast furnace use), and that has an assured outlet for its furnace coke, either through financial affiliation with, or direct ownership by, an ironworks, or through long-time contracts. ''Non-furnace'' plants include: (1) merchant producers of furnace coke who have to sell their output on the competitive market; (2) the plants affiliated with alkali works; (3) all those plants operated as gas utilities; (4) the growing number of plants which, though not public utilities, have been constructed primarily to supply city gas, and which must sell their coke where they can for domestic and industrial as well as metallurgical uses; and (5) a few plants affiliated with local iron furnaces, but producing much more coke than the furnaces can absorb, and, therefore, depending chiefly on the foundry and domestic trade or on merchant sales of furnace coke.

Location of Plants.—Several tendencies may be seen in the location of by-product plants. The primary consideration is that they be near a large market for their products. Most of the Pennsylvania plants are in southwestern Pennsylvania (Figures 35 and 39), depending chiefly upon the coke demands of the iron and steel industry. The Bethlehem plant in eastern Pennsylvania is of similar character. The Pennsylvania plants are, thus, mostly ''furnace'' plants, replacing beehive plants in an area where the demand for coke already existed, and the same may be said of most of the plants west of Pennsylvania which use Pennsylvania coking coal. Two plants in the Philadelphia district, plants in New England and New Jersey, and some of the plants in New York, Maryland, and other states to which Pennsylvania coal is sent are of the ''non-furnace'' variety, growing up where a dense population gives a large demand for coke and its by-products.

The By-Products.—''Much confusion exists in the popular mind as to the nature of the by-products recovered in coke manufacture. The modern coke plant is primarily a producer of specialized forms of fuel. In addition to the main product, coke, it makes another major fuel, gas. Gas is now the most valuable by-product, and at some coke plants its importance is scarcely second to that of the coke itself. The by-product plant recovers a number of crude materials incidental to coke and gas, which it ordinarily turns over to other industries for conversion into finished products. These crudes include tar, light oil (and its derivatives, benzol, toluol, and solvent naphtha), ammonia, naphthalene, and creosote oil, now recovered at a few plants. Occasionally small amounts of crude phenol, pitch, sulphur, sodium prussiate, smoke compound, extil covering, and tar paint complete the list of by-products.

''In this list the dyestuffs and the medicines for which coal-tar derivatives are famous are conspicuous by their absence. The by-product oven is the principal source of the tar and other primary raw materials from which coal-tar dyes and many other organic chemicals are made, but with a few exceptions to which reference will be made

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[2] For example, the by-product coke ovens at Johnstown, Pennsylvania, use a mixture of coal from the high-volatile fields with local low-volatile coal.

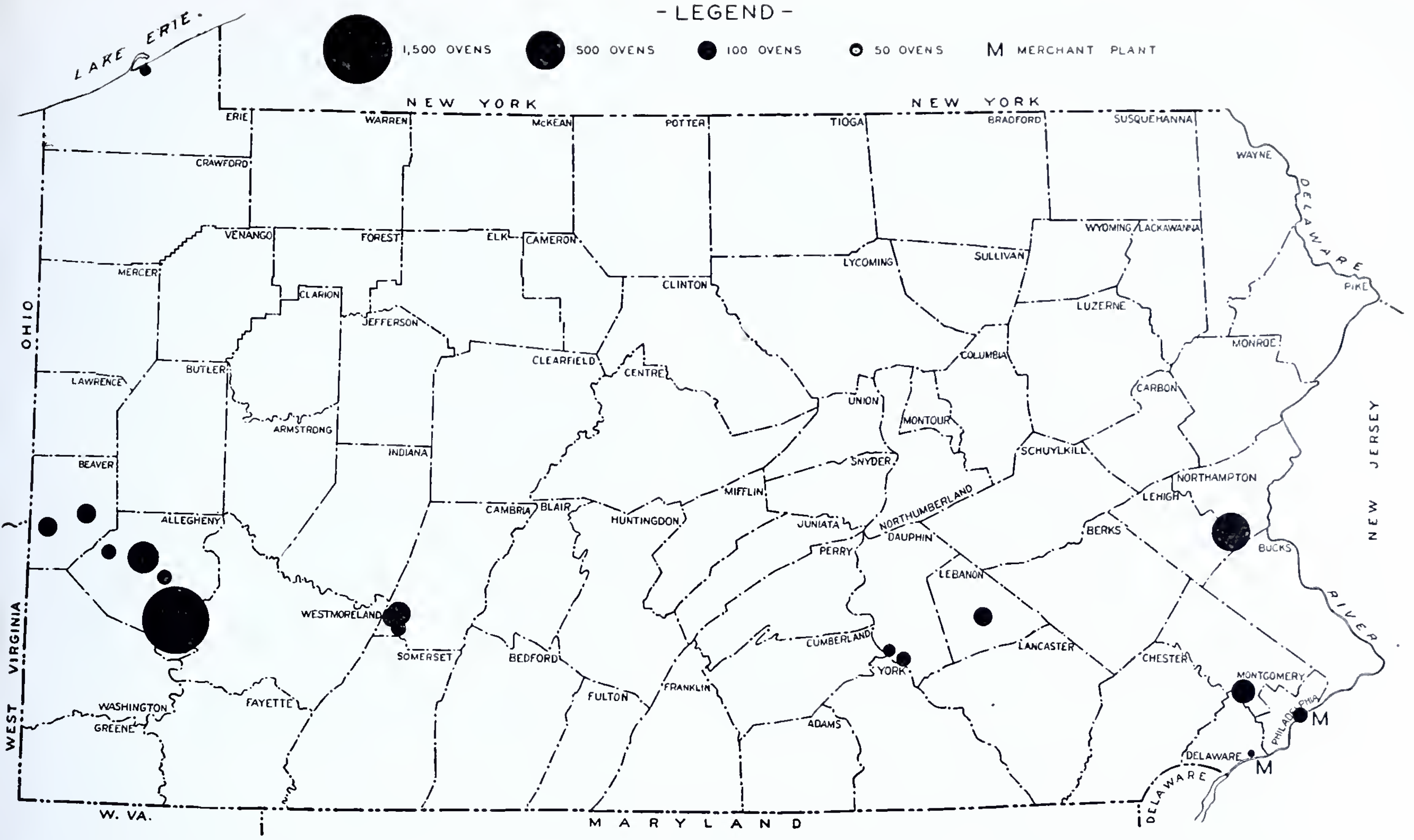

Fig. 39. By-product plants in Pennsylvania in 1929. Areas of circles are proportional to number of ovens. (Data from Mineral Resources of the United States.)

later, these crude materials are turned over to other manufacturers for processing. The typical by-product coke plant strips the light oil from its gas and refines this to make motor benzol or perhaps a little refined benzol, toluol, and solvent naphtha. Its motor benzol usually goes to petroleum refiners for blending with gasoline. Its refined benzol, toluol, and solvents go chiefly to the chemical manufacturing industries. The typical plant also recovers ammonia—usually as sulphate destined for use as fertilizer, less often as ammoniacal liquor—and sells it through certain large distributors. When the naphthalene market is active it is prepared to supply crude naphthalene in indefinitely expansible amounts.

"As for coal tar, the typical plant burns it as fuel, sells it to others for the same purpose, or sells it to a tar distiller, partly because the quantity of tar produced has so increased that it is now much greater than can be absorbed by the ultimate market for coal-tar derivatives and partly because the distillation of tar and the manufacture of dyes and chemicals require highly specialized technology and equipment.

"Until recently, the only important source of creosote oil was the tar refinery, but since 1928 a few by-product coke plants have begun to strip the creosote oil from their tar by a process of fractional condensation that relieves them of the necessity of handling the entire run of tar derivatives. The production of creosote oil from the new source promises to become an important element in the national supply of this indispensable product."[3]

The relative importance of by-products as compared with coke in the by-product coking industry is brought out by Table V. Pennsylvania easily outranks all other states in by-product

TABLE V

VALUE OF BY-PRODUCTS AND OF COKE, INCLUDING BREEZE, PER TON OF COKE PRODUCED IN THE UNITED STATES, 1931.

(Data from United States Bureau of Mines)

Ammonia and its compounds	$0.441
Light oil and its derivatives (including naphthalene)	.447
Surplus gas sold or used	2.084
Tar sold	.384
Tar used, not sold	.253
Miscellaneous products	.049
Breeze produced	.205
Total by-products	$3.863
Value of coke produced	4.886[a]
Total value of coke and by-products	$8.749

[a] Figure given is for coke "produced". The coke "sold" during 1930 brought an average price of $5.799; during 1931, $5.587.

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[3] Tryon, F. G., and Bennit, H. L., Coke and By-products in 1929, Mineral Resources of the United States, 1929, Part II, p. 638.

production just as she does in the production of by-product coke.

In 1929 by-product coke-oven plants in Pennsylvania produced 497,135,077 pounds of ammonium sulphate (or its equivalent), nearly one-third of the United States total thus produced. In the same year these plants produced 65,700,270 gallons of crude light oil, about one-third of such production from coke-oven plants in the entire United States, and this crude light oil yielded 56,580,242 gallons of refined products.

The State's coke-oven gas production for 1929 amounted to 240,552,305,000 cubic feet, about two-sevenths of the total for this product in the United States. Forty per cent of the coke-oven gas which the State produced was used in the coking process; about 3 per cent was wasted; and the remaining 57 per cent was "surplus sold or used". Of this surplus coke-oven gas, 90 per cent was used by steel or other affiliated plants (60 per cent of the total United States coke-oven gas production was so used); 9 per cent was distributed through city mains; and a little less than 1 per cent was "used under boilers".

Pennsylvania produced 231,057,712 gallons of coke-oven tar in 1929, one-third of the United States total. About 60 per cent of this tar was used in open hearth or affiliated plants, in contrast to about 43 per cent for the United States as a whole. Only about one-fifth of the State's production of coke-oven tar was sold, and, of this, half was sold for use as fuel and half for refining tar products.

Lack of markets for by-products has already been mentioned as a limiting factor in the shift from beehive to by-product coking in the United States. The greatest markets for by-products are, in general, in areas of dense population, while the greatest market for coke to date has been the iron and steel industry.

Plants have developed in New England which sell their coke almost entirely for domestic use. This demand, though growing, is still limited and plants of this type are small. Such plants normally have no difficulty in disposing of most of their by-products.

In Pennsylvania the by-product coke industry developed primarily to supply the iron and steel industry with coke. By-products are of minor importance, and, since they are used to a considerable extent by the coke and iron and steel industries, they bring smaller returns than is the average for the United States. In particular, coke-oven gas has had to compete with natural gas in western Pennsylvania; and the average value for the coke-oven gas sold is lower for Pennsylvania than for any other state, $.111 per M. cubic feet in 1929 as compared with $.166 for the United States as a whole. Coke-oven tar, like gas, brings a particularly low price in this section. It is perhaps fortunate that part of the gas and part of the tar can be used as fuel by the coke ovens and steel plants, since this simplifies somewhat the problem of by-product disposal even though these are relatively low-grade uses. Further industrial development may result in more demand and better prices for these by-products, but it is certainly true that at present values of by-products are low in Pennsylvania.

Where the demand for gas warrants it, an interesting development of recent years has been the use of lean gases, such as producer gas, blast-furnace gas, and blue water gas, made from breeze or small coke, for heating the coke ovens, thereby releasing large quantities of oven gas for sale.

Coke Breeze.—Coke breeze results from by-product coking as well as from the beehive process. Its disposal is discussed in the next section with that of coke.

Utilization and Marketing of Coke and Breeze.

The principal use of coke is in the smelting of iron in blast furnaces. In Pennsylvania this use is particularly outstanding (Figure 37), since, as pointed out earlier, most of Pennsylvania's coke plants are "furnace" plants. About 90 per cent of Pennsylvania's coke is sold for furnace use, while only 75 per cent of the total United States production is thus used. Domestic use, foundry use, and miscellaneous industrial uses absorb the remainder of the product.

Consumption of Coke By Iron Furnaces.—In the production of every ton of pig iron approximately 1 ton of coke must be used. In a country with as large an iron and steel industry as that of the United States this means a large market for coke, and the great centers of consumption of furnace coke are naturally the districts producing iron and steel. Outstanding in this consumption are Pennsylvania and Ohio (Figure 40), but New York, Indiana, Illinois, Alabama, and Michigan are also important users of furnace coke.

There has been, within recent years, a steady decline in the consumption of fuel per ton of pig iron made, and this has, of course, affected the market for furnace coke. The decline is due partly to the increasing burden of scrap, but also represents improvements in the yield and quality of the coke. The net result of these savings has been to more than offset increases in tonnage of

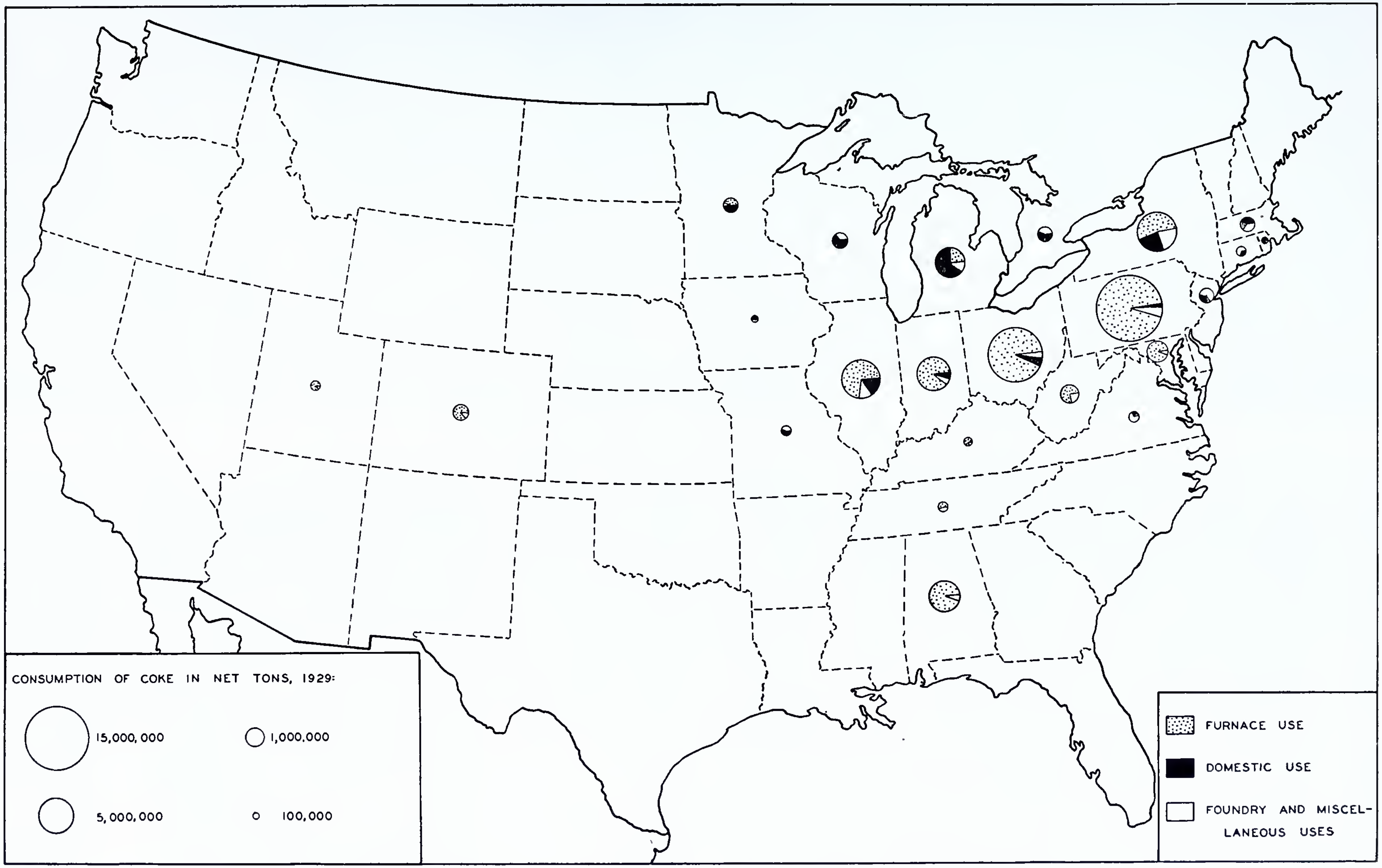
CONSUMPTION OF COKE IN NET TONS, 1929:
15,000,000
1,000,000
5,000,000
100,000
▨ FURNACE USE
■ DOMESTIC USE
□ FOUNDRY AND MISCELLANEOUS USES

Fig. 40. Map of United States showing consumption of coke by states and character of consumption in each state, i. e., furnace coke, domestic coke, etc. (Data from Mineral Resources of the United States.)

iron produced, so that the annual consumption of coke for this purpose in recent years has shown no consistent gain.

Little by-product furnace coke is shipped, since there is an increasing tendency to ship coal to the ovens and consume the coke near the ovens without loading for shipment. Thus, Ohio and New Jersey were the only states receiving Pennsylvania by-product coke for furnace use in 1929 (together they received about 800,000 tons.) On the other hand, beehive coke is normally made at the mines and the great bulk of the beehive coke produced must be transported some distance to reach its place of use. Though the beehive coke production of Pennsylvania was only about one-sixth as great as the State's by-product coke production, a total of over 1,000,000 tons of beehive coke of furnace grade[4] from Pennsylvania was shipped to Ohio, New York, New Jersey, Washington, D. C., Maryland, Michigan, West Virginia, Virginia, Wisconsin, Illinois, Indiana, Massachusetts, and Connecticut in 1929.

Use of Coke by Foundries and For Other Industrial Uses.—Foundry coke is used in cupolas for the melting of metals. Such use is a minor though necessary item of coke consumption. There has been little change in the total use for this purpose within recent years, and the same is true of coke for miscellaneous industrial purposes. The latter group of uses, which includes water-gas manufacture, is likely to be particularly important in areas which lack a local coal supply or an adequate supply of natural gas, e. g., New England and New York City.

Domestic Use of Coke.—The most remarkable change in the coke market of recent years has been the rapid expansion in household demand. This newly arising market is located principally in the area north of the Ohio and Potomac rivers and east of the Missouri (Figure 40). From less than 2,000,000 tons ten years ago, the consumption of by-product and beehive coke in the United States for domestic use increased to 6,826,000 tons in 1929. In addition, 518,000 tons were exported for domestic purposes, chiefly to Canada, making a total of 7,344,000 tons destined for household use in 1929. Nineteen hundred thirty figures indicate a further increase to over 8,000,000 tons.

This increase in domestic use of coke is really striking, particularly in view of the shrinking of markets for furnace coke. Yet it is not surprising that coke should invade this field, since the consumption of fuel for heating buildings is the largest single item in the national demand for energy, exceeding even the requirements of the railroads. It is, therefore, sure to be a great battle ground for the struggle between anthracite, bituminous coal, gas, coke, and the other competitors. This competition is discussed in more detail in the chapter on anthracite. As pointed out earlier, the domestic market is not only large, but it is growing and its rate of growth is faster than the rate of growth of population.

The domestic fuel market is said to exhibit three distinct tendencies at the present time: an increasing proportion of the population is living and working in large buildings that can readily be heated by central heating installations; there is an increasing demand for fuels that will not smoke; and, perhaps most important, the consumer is beginning to appreciate the luxury of automatic heating with oil, gas, and small automatic stokers adapted to solid fuels.

Coke as a domestic fuel has a number of advantages over both hard and soft coal. The locality in which anthracite is found is irrevocably fixed, hence, distance from the source of supply to the points of consumption will never be lessened. On the other hand, by-product coking plants can be located either at the place of coal production or else in the area of greatest consumption, in the latter case coal being shipped to them. Coals suitable for by-product coking are widely situated geographically so freight rates are, on the average, less than those applying to anthracite. Coke is much cleaner than soft coal, and is more easily handled than either type of coal because of its light weight. It is comparable to anthracite in being smokeless. Moreover, it can be furnished at a lower cost than comparable sizes of anthracite. This last, very critical advantage, together with education of the public in methods of firing coke, seems to account very largely for the rapid rise in the domestic use of coke within recent years.

Active competition between the several fuels is tending to force prices down. Prices of fuel briquets, low-volatile bituminous coal, Pennsylvania anthracite, and the anthracite and semi-anthracites of other states are all moving downward. The decline in prices of domestic by-product coke in recent years has been still more pronounced, although in 1929, under the stimulus of the general activity of business, the price recovered slightly. On the other hand, prices of domestic burning oil increased slightly in 1929.

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[4] It must be borne in mind that the terms "furnace coke" and "foundry coke" as used in the trade refer to size and grade of the coke as well as to the use for which it may be intended. Thus, small sales of "furnace coke" were made to states which have no blast furnaces, such coke probably being used for domestic purposes. Such discrepancies, however, are of small magnitude.

Michigan, New York, and Illinois are the leading consumers of coke for domestic purposes (Figure 40), but New England, New Jersey, Canada, Wisconsin, Minnesota, and a number of other states consume important quantities.

In Pennsylvania, competition with bituminous coal, anthracite, and, to a lesser extent, with other fuels, has kept coke consumption for domestic purposes down to a small figure. However, the State is directly interested in this market in other states in two respects. It sends considerable coal to other states for coking, and part of the coke thus made enters the domestic fuel market. In the second place, Pennsylvania sent beehive coke for domestic use to sixteen other states in 1929, and to five of these it sent some by-product coke also for the same use. Massachusetts, New York, Michigan, and Ohio led in receipts of coke from Pennsylvania for domestic use in 1929, but New York, which received the most, received only 30,000 tons, and several of the sixteen states mentioned above received less than 100 tons each.

It must be remembered that in spite of the rapid increase in consumption of coke for domestic purposes, the tonnage for this purpose is still but a small fraction of the total consumption of all fuels for house heating. Thus, there is reason to believe that the market for domestic coke is far from the saturation point. Pennsylvania's chief opportunity for gain in this market in the future seems to lie in the sale of coal to by-product plants in areas which do not have a supply of fuel of their own. True, this will displace some anthracite and bituminous coal, but a continued increase in the use of coke for domestic purposes seems inevitable.

Consumption of Breeze.—It has been pointed out that a ton of bituminous coal coked in a beehive oven yields, in addition to coke, about 80 pounds of breeze (screenings too fine for metallurgical or household use), and that the same amount of coal coked in a by-product oven yields, in addition to coke and by-products, about 130 pounds of breeze. The size of the material classed as breeze varies with the different plants, but it may be described roughly as corresponding to the steam sizes of anthracite.

Uses ordinarily can be found for the breeze produced at by-product coke plants, and the amount wasted is negligible. By-product coke-oven plants in Pennsylvania produced 1,596,203 net tons of breeze in 1929, valued at $2,781,319. Eighty-six per cent, by weight, of this breeze was used by the producers principally for steam raising, 12 per cent was sold, and 2 per cent remained on hand December 31st.

In the beehive branch of the industry the problem of finding a profitable outlet for breeze remains unsolved. The production reported for Pennsylvania in 1929 was 214,193 net tons considered as having a value of $170,529, but 64 per cent of this production remained on hand December 31st. Limited amounts of the breeze produced in beehive ovens are used by the producers in steam raising and for other purposes, and even smaller quantities are sold.

Transportation.

The beehive industry usually requires transportation of its product from ovens to consumer. Most of such transportation was, and is, done by rail, but a small amount of beehive coke is transported from the Connellsville field to the Pittsburgh district by means of the Monongahela River.

In the by-product industry a large part of the coke produced is consumed close to the ovens and is not loaded for shipment. The remainder is shipped by rail, and, to a very limited extent, by water. Water shipments in Pennsylvania are practically limited to the Monongahela and Delaware rivers.

It was recommended by the United States Coal Commission in 1923 that consideration be given by the railroads to the establishment of coking-in-transit rates. Such a rate would be a competitive through rate by which coal would be carried from mines to ovens, and, after conversion into coke, transported beyond to the consumer. It would be like the "milling-in-transit" rates by which wheat is transported to the mills, converted to flour and several by-products, and the flour carried beyond to consumers. It was considered that coking-in-transit rates would advance the by-product coking industry and the conservation of natural resources.

Foreign Trade in Coke.

American coke companies exported 947,456 net tons of coke and breeze in 1929. Ten per cent by weight of this total was breeze, the remainder coke, 60 per cent of the coke being for domestic use, the other 40 per cent for miscellaneous industrial uses, for foundry use, and for furnaces.

Eleven different states participated in the export trade, the largest shipments moving from Michigan, New York, Pennsylvania, and Ohio. Ninety-seven per cent of the total coke exported went to Canada.

Imports, amounting to 119,724 net tons, were received principally at Pacific coast ports and states of the northern Rocky Mountain group.

Future of the Coke Industry.

A continued increase in household use of coke is the most striking feature on the industry's horizon. Pennsylvania's natural fuel supplies will probably keep this market from growing as rapidly within the State as it does elsewhere in northeastern United States. It seems, therefore, that Pennsylvania's principal part in the development will be the shipment of coal for use in by-product plants located in New England, New York, and elsewhere in the areas of maximum demand for household coke. The southern fields (in Virginia, West Virginia, and Kentucky) have been making serious inroads in the New England bituminous coal market; they are serious competitors, also, in the Middle West and Lake states. It remains to be seen, therefore, to what extent Pennsylvania can participate in this growing coke market. It appears that a lowering of production costs, a reduction of freight rates, or both will be necessary to put the Pennsylvania fields on a parity with the southern fields in these several markets.

The curves of by-product coke production and all coke production for Pennsylvania have been coming closer and closer together (Figure 38). The beehive coke oven has served its purpose and now seems destined to pass out of existence. This fact colors the whole future of the industry of Pennsylvania. Though Fayette County must eventually give way as premier coal producer to Greene and Washington counties with their larger reserves, it is unlikely that these counties will ever be important coke producers. Instead, their coal will be sent to by-product plants conveniently located with respect to markets.

A gradual movement of the iron and steel industry to the Atlantic Coast has been predicted (see chapter on iron and steel industry). Such a movement, when and if it comes, may give the southern fields an advantage in the furnace coke market, since, if one may judge by the situation in New England, they will be able to deliver coal by rail and tidewater at Atlantic coast points at lower prices than can the western Pennsylvania fields. Such developments, however, are not likely to occur in the near future.

The Manufactured Gas Industry

What should be included in the manufactured gas industry? Natural gas obviously does not belong. It will be discussed later in a separate chapter. There remain as important commercial gases: coke-oven gas, coal gas, blue water gas, carburetted water gas, producer gas, blast-furnace gas, and oil gas.

The Uses of Manufactured Gas

Gas was once of great importance as an illuminant. In this field it has been succeeded by electricity, but there still remain many critical uses. Gas is in many respects an ideal heating agent. It is convenient to control, cleanly, and can be used more efficiently in proportion to its heat content than most other fuels. On the other hand, it cannot compete with electricity as a form of power distribution any more than it can as a lighting agent.

First among the uses of gas, we must list "domestic purposes"—which include cooking, water heating, house heating, and other uses in the home. For such purposes natural gas, manufactured gas-natural gas blends, and manufactured gas alone are being marketed. Although the number of houses heated with manufactured gas is still small, the movement is increasing at a rapid rate. The high cost of installation and high fuel bills militate against the use of manufactured gas for house heating, and indicate that gas heating is a luxury; but it is evidently one for which many families will gladly pay in order to be rid of the labor of stoking a fire and handling ashes.

In the field of industry, gas is rapidly gaining favor. In the enamel, glass, heavy clay products, refractories, and white wares division of the ceramic industry, gas is particularly important since it has the great advantage of adaptability to accurate temperature and furnace atmosphere control. It is important in the manufacture of glass and innumerable glass products. All heat operations in the manufacture of steel and steel products and in the treatment of metal are being done with gas. The trend of industry is toward the use of automatic equipment for heat-treating operations; and gas, because of its adaptability to automatic operations, is being extensively used.

Relation of the Industry to By-product Coking

It is difficult to draw a hard and fast line between the by-product coke industry and the manufactured gas industry. The by-product coke industry produces important amounts of gas as a by-product; while, on the other hand, most gas-making processes involve the making of coke or the use of coke. Such coke, however, is not ordinarily of metallurgical grade.

The by-product coke industry, as discussed early in this chapter, included all by-product coke-oven plants, even where they are operated by city gas companies to supplement or even replace their coal or water gas plants. The coke which these city gas companies produce in their by-product plants is superior to gas-house coke and is marketed for household, foundry, or furnace use in competition with other cokes of metallurgical grade. This is the point of view taken by the United States Bureau of Mines.

On the other hand when the manufactured gas industry is being discussed, there is some justification for considering by-product coke plants operated by city gas companies as merely a part of the manufactured gas industry. They are so considered by the United States Census and since Census figures are the only ones available for the manufactured gas industry, the industry will be considered here as including these by-product ovens operated by gas utility companies. It must be borne in mind, however, that there is some overlap. This overlap is not important in Pennsylvania, since all but the two Philadelphia plants are affiliated with iron furnaces; there is considerably more overlap in New York where part of the plants are "furnace" and part "non-furnace", and in New England and New Jersey where all the by-product plants are "non-furnace".

The Manufactured Gases

Coke-oven Gas.

Coke-oven gas is one of the by-products of by-product coking. Most of this gas is used in the coking process or sold to steel or other affiliated plants. However, many by-product plants sell some coke-oven gas to utilities companies to supplement the other supplies of these companies, and there has been a tendency within recent years for gas companies to purchase more and more coke-oven gas. Of course, when the coke-oven plant is operated by a city gas company all the gas not used around the plant goes into the city mains with the exception of some sales direct to industrial concerns. Coke-oven gas is fairly rich, with an average B. t. u.[5] value of about 583.

Coke-oven gas is, in fact, a manufactured gas. As already explained, however, since it is an incident to coke manufacture, it is not considered a manufactured gas by the Census, unless the by-product plant is operated by a city gas company.. In the general discussion of the manufactured gas industry later in this chapter, it should be kept in mind that the figures given do not include coke-oven gas or its manufacture except where such gas is made in by-product ovens operated by city gas companies.

Coal Gas.

This gas, often referred to as illuminating gas or city gas, is made by distilling bituminous coal in an air-tight retort. The gas, which has a heating value of between 500 and 600 B. t. u. per cubic foot, is driven from the coal leaving a coke residue in the retorts. The process of manufacture is essentially the same as that in by-product coke ovens, though the type of oven is different. Moreover, the emphasis is upon gas production, so the coals used are selected for their yield in gas rather than for their coking properties. The coke formed is too soft for metallurgical use, but may be sold as hard fuel or may be used as a raw material for the manufacture of water gas. Coal gas production does not lend itself readily to intermittent operations, and best results are secured when production of the gas is carried on at a fairly uniform rate.

Blue Water Gas.

Blue water gas is made by passing steam through a large chamber filled with glowing hot coke (or anthracite). The process is intermittent, the coke first being made white hot by forcing air through it, after which the air is shut off and the steam passed through. The resulting gas usually has a heating value of about 300 B. t. u. per cubic foot. All of the coal or coke used in blue water gas manufacture is used up in the process, so there is no problem of marketing coke. The intermittent character of blue water gas manufacture makes this process extremely flexible and well adapted to providing for peak load demands.

The chief use of blue water gas is in the manufacture of carburetted water gas. It has, however, two further important fields of use: (1) as an auxiliary to city gas plants making coal gas, and (2) as an industrial gas where high calorific intensity is essential. Because of low heat value (and, consequently, large volume necessary to accomplish a given amount of heating) blue water gas can be used only at or near the point of production. The use of water gas for the manufacture of motor fuels and other commodities, although just being developed, seems to have great future possibilities.

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[5] British thermal unit, or amount of heat required to raise the temperature of 1 pound of water at its maximum density 1 degree Fahrenheit. Heating value is commonly described in these units. The average manufactured gas delivered in the United States has a heating value of about 500 B. t. u. per cu. ft.; the average natural gas, 900 to 1000 B. t. u. per cu. ft.

Carburetted Water Gas.

Blue water gas enriched with gasified oil is called "carburetted water gas". Such gas varies in heating value depending upon the amount of oil added, but 400 to 600 B. t. u. per cubic foot is a fair average. Carburetted water gas constitutes, at the present time, more than half the total of all gas manufactured for public distribution in the United States. It is used almost exclusively as a city gas, in the same way as coal gas, many towns distributing mixtures of the two. The process has the same flexibility of output as blue water gas manufacture, but is more costly. This flexibility effects a saving through permitting a minimum gas storage capacity.

Producer Gas.

Producer gas is generated by blowing a mixture of air and steam up through a thick, hot bed of coal or coke. Producer gas manufacture, like the manufacture of water gas, uses up all of the coal. Producer gas has a large volume of nitrogen and hence the heat value is low, about 140 to 185 B. t. u. per cubic foot. Its low heat value and the large volume that must be used to get much heat prohibit use of this gas any considerable distance from the point of manufacture.

Producer gas is the cheapest form of industrial gas that can be manufactured. It possesses, in general, the advantages of all gaseous fuels; and, in consequence, it finds wide application in industrial heating. It is used mainly either where a gaseous fuel is the most economical source of heat or where coal cannot be used and a cheap gas is necessary.

The United States Census does not report producer gas manufacture, since it is commonly not delivered through mains but is made in the manufacturing plant which uses it. Hence, data are not available as to its production in Pennsylvania. It has been estimated, however, that there are about 11,000 producers (operating units) in the United States, and the distribution of these producers in the various industries has been estimated[6] as follows:

Industry	Number of Producers
Steel	6,500
Glass	1,500
Ceramics and lime burning	1,500
Power generation	1,000
Metallurgical and other chemical fields	500
Total	11,000

Blast-furnace Gas.

Blast-furnace gas is a by-product of the smelting of iron ore, and is used mainly in supplying power at the smelter, in operating by-product plants, or is piped to a steel plant where it is used in open-hearth steel manufacture. It is a very lean gas, its B. t. u. value being about 90 per cubic foot. No data are available on the amount of blast-furnace gas produced.

Oil Gas

Oil gas does not result from coal processing, but it is a manufactured gas so is mentioned briefly here. It is made by the thermal decomposition or "cracking" of hydrocarbon oils into lighter, fixed hydrocarbon gases. It ordinarily has a heating value of from 450 to 650 B. t. u. per cubic foot.

The main outlet of oil gas is in place of coal gas for distribution through city mains. On the Pacific Coast, where oil is the only cheap fuel, large quantities of oil gas are used as city gas. In eastern United States, where oil prices are higher and coal is abundant, oil gas is of very minor importance.

Average Manufactured Gas.

The average manufactured gas as delivered to consumers in eastern United States consists of a mixture of coal gas and water gas, and of by-product coke-oven gas where the latter is available. The heating value standard most commonly used in the United States is in the vicinity of 500 to 550 B. t. u. per cubic foot. The present tendency, however, is toward lower standards.

Importance of the Manufactured Gas Industry

The production and consumption of manufactured gas has been steadily increasing. This is to be expected, since gas is growing in popularity as the accessible supply of natural gas declines.

The manufactured gas industry as considered by the United States Census includes only "establishments, both private and municipal, engaged primarily in the commercial manufacture of gas to be delivered through mains, for illuminating, household, and industrial purposes. It does not cover establishments which merely distribute gas not of their own manufacture." This definition excludes blast-furnace gas, nearly all producer gas, and all by-product coke-oven gas except that small proportion which is made in by-product plants operated by city gas companies. Even when thus restricted, the value added by manufacture of the manufactured gas industry of the United States in 1929 was $324,236,412, more than twice as great as "value added by manufacture" for the coke industry. In Pennsylvania, the "value added by manufacture" was $25,684,848, about one-third less than "value added by manufacture" for the coke industry. Six thousand five hundred persons were engaged in the manufactured gas industry in Pennsylvania in the year 1930.

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[6] Chapman, W. B., Fuel Saving in Modern Gas Producers and Industrial Furnaces, Mechanical Engineering, Vol. 43, 1921, p. 717.

Location of Industry

In speaking of the location of the manufactured gas industry the gas under discussion is that considered by the Census—coal gas and water gas (the latter largely carburetted), together with coke-oven gas where the coke oven is operated as part of a city gas system.

The areas of densest population and greatest industrial development, particularly where these areas are lacking in natural gas, are the most prominent gas manufacturing areas. The state of New York led in value added by manufacture in 1929; Illinois followed with a little more than half as large a production as New York; while New Jersey was third. Though Pennsylvania is the second state in population, it is but fourth in manufactured gas production, principally because western Pennsylvania produces a considerable amount of natural gas, and because the State produces large amounts of several fuels which compete with gas. Massachusetts, Michigan, and California followed Pennsylvania, the order suggesting that there is a close relationship between manufactured gas production and population, except in a state like Pennsylvania which has bituminous coal, anthracite, and some natural gas, or like Texas with abundant natural gas.

Only three or four of the fifty to sixty manufactured gas plants in Pennsylvania lie west of the center of the State, and these few plants are small. On the other hand, manufactured gas plants are markedly concentrated in the southeast, in that section of the State which is not served by natural gas and which does not have easy access to bituminous coal.

If we should include all establishments where gas is manufactured by any process or for any purpose the distribution would be much wider. By-product coke-oven gas is, of course, manufactured at all the by-product plants in the State (Figure 39); producer gas is made at many industrial plants in western Pennsylvania as well as elsewhere in the State; and blast-furnace gas results from operation of the various blast furnaces of the State (Figure 91).

Consumption of Gas-making Materials and Fuels

The manufactured gas industry as defined by the Census consumes coal, coke and breeze, oil, and tar. In 1929 the industry in Pennsylvania used the following for the purposes indicated:

Coal (short tons)	Anthracite	30.165	tons—material
		31.799	tons—fuel
	Bituminous	182.939	tons—material
		19,651	tons—fuel
Coke and breeze (short tons)	Produced in plant	48.069	tons—material
		18,738	tons—fuel
	Purchased	184.193	tons—material
		4,792	tons—fuel
Oil (bbls. of 42 gals.)	Material	Gas making	2,234
		Carburetting,	1,431.343
	Fuel		408,802
Gas tars (bbls. of 42 gals.)	Fuel		4,883

Products of the Manufactured Gas Industry

The products made for sale by the manufactured gas industry include not only gas, but coke, screenings and breeze, tar, and some minor by-products. In 1929 the manufactured gas industry of Pennsylvania (in the restricted sense of Census usage) produced for sale 30,728,423 000 cubic feet of gas and the following by-products: 122,776 short tons of coke, 3,659,507 gallons of coal-gas tar, 4,014,330 gallons of water-gas tar, and some other, minor by-products. The gas, with a total value of about $33,814,178, constituted nearly 90 per cent of the total value of products.

Purchase of Gas by Manufactured Gas Companies

Manufactured gas producing companies have been purchasing more and more of the gas which they sell. Since 1926 there has been a gradual decrease in the amount of manufactured gas produced; during the same period there has been a very rapid increase in the amount of coke-oven gas and natural gas purchased. It is expected that figures for 1931 will show that the manufactured gas industry purchased more gas than it produced during that year.

Where Is Manufactured Gas Consumed?

Manufactured gas is not piped long distances. The areas of maximum consumption, therefore, are almost identical with those of maximum production.

Transportation

Manufactured gas is transported in pipe lines. Usually such gas is not sent very far. To serve a large consuming city a considerable distance away with gas of the average B. t. u. value of distributed manufactured gas would require too large a pipe line capacity. Instead, manufactured gas plants are located at population centers, and the chief transportation is through the city mains. Underground storage (See p. 93), where possible, effects a saving through lessening the required capacity of pipe lines which must be built.

Problems and Trends of the Industry

The manufactured gas industry has a number of problems to face.

Seasonal Demand.

The problem of seasonal demand is one of the most serious of these, especially where much of the gas is sold to domestic users. This situation requires the erection of a plant large enough to take care of a peak load during a few days of severely cold weather, thus leaving considerable idle capacity of a portion of the plant for a large part of the year. The association of coal-gas and water-gas plants solves this problem to some extent since the water-gas manufacture can be carried on intermittently to satisfy peak demands. The excess summer capacity of gas plants must be put to productive use in some way. Refrigeration and house cooling have been suggested as possibilities.

Where exhausted oil or gas sands are available, this problem can be met by storing the manufactured gas underground during times of small demand, thus making possible the meeting of peak load requirements without excess plant capacity. Moreover, existing evidence seems to show that the gas that has been thus stored is likely to have a slightly higher B. t. u. content than before storage. The use for storage of sands which have never contained oil or gas does not seem feasible in the light of present knowledge.

The Nature of the Gas Delivered.

The gas delivered to consumers by manufactured gas companies is not one gas but a mixture of several. Nor are the gases thus mixed necessarily manufactured by the distributing company. Instead, it has been pointed out that an increasingly large proportion is purchased coke-oven gas or natural gas, the amount of purchased gas now being about equal to the amount of gas manufactured by the gas companies.

Future of the Industry

It seems probable that manufactured gas, either made by manufactured gas companies or made as a by-product of coke manufacture, will increase in importance in the future, since appreciation of gas as a fuel is growing. Opposed to this increase, however, will be the competition of other fuels, particularly natural gas. Though the supply of this fuel in eastern United States is declining, new fields are being developed elsewhere and long-distance pipe lines are making transcontinental transmission possible.

Low-Temperature Carbonization

Low-temperature carbonization of coal is defined as the heat treatment of coal in the absence of air at temperatures of 840 to 1290 degrees Fahrenheit. The aim is to keep the temperature low enough to prevent, as far as possible, the decomposition of the primary tar, thus obtaining the maximum yield of liquid products. At 840 to 930 degrees Fahrenheit, the tar yield is two or three times that of the ordinary high-temperature coking or gas-making process.

Tar can be cracked into lighter motor oils. Though we now produce large amounts of petroleum from our underground resources, reserves are much more limited than those of coal. Low-temperature carbonization of coal may some day be necessary for the continuation of our highly-developed system of automotive transportation, though it now appears that processes involving liquefaction of coal are better adapted to meet the need.

A comparison of the products from high-temperature and low-temperature carbonization is shown in Table VI. A high-grade, smokeless fuel, greater in quantity per unit of coal than results from high-temperature carbonization; gas of

TABLE VI
COMPARISON OF PRODUCTS FROM HIGH- AND LOW-TEMPERATURE CARBONIZATION[a]

Product	High-Temp. Carbonization	Low-Temp. Carbonization
Coke:		
Lbs. per 100 lb. coal	65-75	75-80
Pct. volatile matter....	1-3	7-15
Gas:		
Cubic feet per ton....	10,000-13,000	4,000-6,000
B. t. u. per cu. ft.......	530-600	700-900
Light oil and tar, gallons per ton..........	10-17	20-40
Ammonium sulphate, pounds per ton..........	24-26	12-15

[a] Haslam, R. T., and Russell, R. P., Fuels and their Combustion, 1926, p. 668.

higher heating value but smaller volume than the gas from an equivalent amount of coal treated by the high-temperature method; two or three times as much light oil and tar as results from the high-temperature process; and a somewhat smaller quantity of ammonium sulphate—these are the products of low-temperature carbonization.

Coal is a poor conductor of heat, and the chief difficulty in the process of low-temperature carbonization lies in transferring the heat to the coal in a reasonable time when using a relatively low temperature gradient. Chiefly as a result of this, low-temperature carbonization costs more than high-temperature carbonization at the present time; and there is no commercial operation of this sort either in America or Europe. It remains for improved technology or for future greater demands for its products to give the process commercial importance.

Liquefaction

In some of the European countries where natural petroleum is scarce the conversion of coal into liquid fuels is receiving considerable attention. Without going into detail, we may say that progress in this field has been along two lines, both of European origin. One proposed the complete gasification of coal and conversion into liquid hydrocarbons by synthesis; the other proposed conversion of the solid substance into liquids by introducing hydrogen into the coal under high pressures and temperatures.

The extent to which coal will rival petroleum as a source of liquid fuels depends upon the cost of production of refined oils from each of these two raw materials. In Europe the process has entered the commercial stage; in the United States petroleum is still too abundant and cheap for oils made from coal to be important.

VI

THE PETROLEUM INDUSTRY

Introduction

"Petroleum possesses peculiar value to society because it is the sole commercial source of gasoline, which has made possible the spectacular development of the motor-driven vehicle; because it yields lubricants, without which the wheels of industry literally could not turn; because it supplies the world with kerosene, which outside of cities and highly industrialized areas still remains the chief illuminant; and finally, because it yields fuel oil, which has become in certain sections of the country and for certain uses an essential, almost indispensable source of power."[1]

For purposes of discussion, the petroleum industry may be subdivided into production, transportation, and refining.

Production deals with the obtaining of crude oil from the ground and is an extractive mineral industry, comparable to coal mining. The estimated value (at wells) of crude oil produced in the United States in 1931 was $550,630,000, just a little less than the value of bituminous coal at the mines. Transportation consists of the movement of crude oil to the refineries and to other users of the crude product.[2] Refining, or the making of useful products from crude oil, is a great manufacturing industry, having a "value added by manufacture" in the United States in 1929 of $555,946,754, which gives petroleum refining a rank of about fourteenth among the manufacturing industries of the United States for that year.

The petroleum industry, including as it does production, transportation, and refining, is truly a giant industry, a fact to which the total value of products of petroleum refining in the United States, $2,611,680,940 in 1929, gives striking testimony.

All three branches of the petroleum industry are represented in Pennsylvania. The State produced 11,892,000 barrels of crude petroleum in 1931 with an estimated value (at wells) of $23,550,000, thus ranking eighth in bulk of production with 1.4 per cent of the United States total, and fifth in value of production with 4.3 per cent of the United States total. The high grade of lubricants made from Pennsylvania petroleum and the nearness to markets accounts for the State's higher rank in terms of value than in volume. Pennsylvania crude oil not only makes the highest quality lubricants, but also has a lubricating oil content of approximately 23 per cent as compared with a 3 per cent average for the United States.

Pipe lines form an important part of the petroleum industry, and although transportation cannot be definitely evaluated it is an integral part of the State's petroleum industry, linking, as it does, production and refining.

The "value added by manufacture" for Pennsylvania's petroleum-refining industry in 1929 was $48,215,658, nine per cent of the United States total. In petroleum refining, Pennsylvania, with a rank of fourth among the states, is of greater relative importance than in crude oil production. This is accounted for chiefly by the importation of crude oil by southeastern Pennsylvania refineries, and, to some extent, by the western Pennsylvania refineries as well.

Of what importance is the petroleum industry to Pennsylvania? As an extractive mineral industry it is exceeded in value of products only by the anthracite and bituminous coal industries (and by common rocks if these are considered collectively)—the anthracite produced in Pennsylvania (in 1931) having a value at the mines 12½ times as great as the value of the petroleum produced; the bituminous coal, a value about 6½ times as great as petroleum. Petroleum production in Pennsylvania employs a large number of persons—over 4,000 in McKean County alone[3]—although exact data on this point are not available. Transportation cannot be evaluated, but it is of unquestionable importance both in persons employed and in the value it adds to the product. Petroleum refining, the other branch of the petroleum industry, ranked twelfth among Pennsylvania's manufacturing industries in 1929, with a "value added by manufacture" equal to 1.4 per cent of the State's total. About 9,500 persons were employed in the petroleum-refining industry in the State in 1929 according to the United States Census.

The State of Pennsylvania has played an important part in the petroleum industry of the United States. As will be described later, the first well drilled for oil in the United States was in Pennsylvania, and the first commercial petroleum refining was carried on with the oil obtained. Pennsylvania was thus the mother state of the petroleum industry. Moreover, methods and tools developed in the early Pennsylvania fields are in use in every section to which the industry has spread; men who received their training in Pennsylvania fields have drilled many of the wells in Mid-Continent and other fields, and have trained other men who are carrying on the work; superintendents and other executives in charge of operations in the various fields got their start, in a surprisingly large number of cases, in the Pennsylvania fields; and many of the large oil companies were founded with the experience and capital gained in the oil fields of Pennsylvania. Truly, Pennsylvania has played a vastly more important role in the petroleum industry than mere production figures indicate.

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[1] Stocking, George W., The American Petroleum Industry, in Representative Industries in the United States, edited by H. T. Warshow, 1928, p. 530.

[2] Movement of refinery products to consumers is discussed in the section on refining.

[3] Estimate by the author based upon United States Census data.

History of the Petroleum Industry In Pennsylvania

Seepages of petroleum have been known in Pennsylvania for hundreds of years. Native Indians used oil for medicinal purposes before the arrival of white people, and early white travelers reported "oil springs" along Oil Creek in Venango County, and elsewhere. As settlers moved into western Pennsylvania they eagerly sought whatever natural resources the region contained. One of the products most in demand was salt, so salt-water wells were dug, and, later, salt was obtained by drilling. From these salt-water wells and from seepages some petroleum was obtained, but it had little or no market, a very small amount being sold for medicinal purposes.

About 1854 attention was given to experiments with petroleum as a source of "coal oil" or kerosene, small amounts of which were then being distilled from coal, and it was found that kerosene could be successfully distilled from petroleum. Capital was available, but there was not enough petroleum produced from any source to permit the establishment of a refinery of commercial importance. To secure enough petroleum for a refining industry, the Seneca Oil Company with Colonel E. L. Drake as its superintendent drilled the first oil well. It was located in northern Venango County near Titusville, Pennsylvania. Completed August 28, 1859, the well, when equipped for pumping, produced at the rate of about 25 barrels per day, the oil commanding a price of about sixteen dollars per barrel. Drake's contribution was his development of a method of obtaining petroleum cheaply and in quantity by boring. In so doing he began our oil industry as we know it today.

Beginning in 1860 many wells were drilled along Oil Creek, French Creek, and the Allegheny River, and the industry gradually spread. Supplies of crude oil soon exceeded the demand, and a slump ensued; then the completion of a number of new refineries stimulated demand and the industry again throve. Until 1878 production was confined to the northwestern part of the State, but later it spread southward, keeping always within a fairly definite northeast-southwest belt (See Figures 41 and 42).

In 1891 Pennsylvania oil production reached its peak, with a total of 31,000,000 barrels (Figure 43). Then for a long period it declined, regardless of a fairly steady price rise. After about 1911 the curve of production became almost flat, though the actual low ebb was not reached until 1918, in which year the production was only 7,408,000 barrels. From 1925 to 1930 there was a steady increase in production, due principally to water flooding operations in the Bradford Field. As a result of the use of these secondary recovery methods, the 1930 production reached 12,803,000 barrels, the highest total since 1900.

In 1891 Pennsylvania produced 58 per cent by bulk and 69.6 per cent by value of all petroleum produced in the United States. In the years that followed, as production shifted to the Middle West and to the Mid-Continent and other fields,

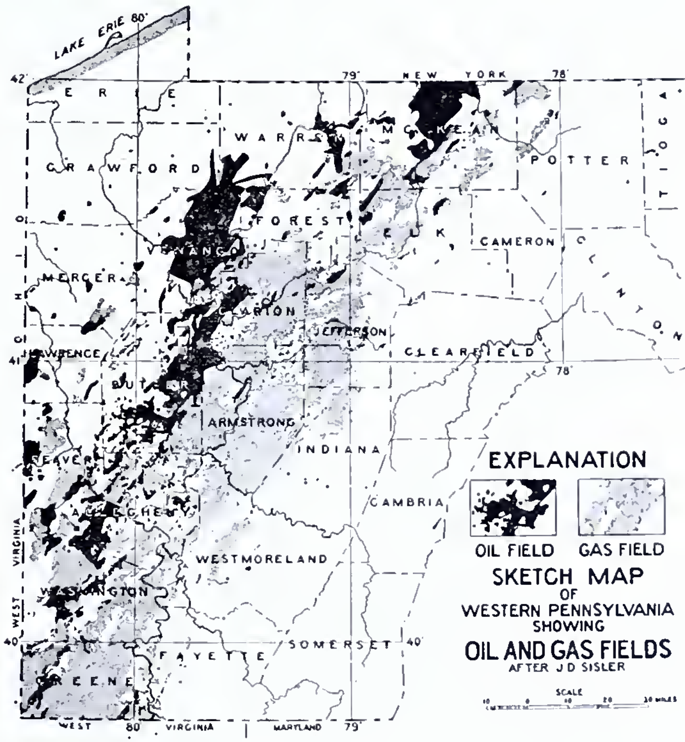


Fig. 41. Generalized map of oil and gas fields of Pennsylvania. (Courtesy of Pennsylvania Geological Survey.)

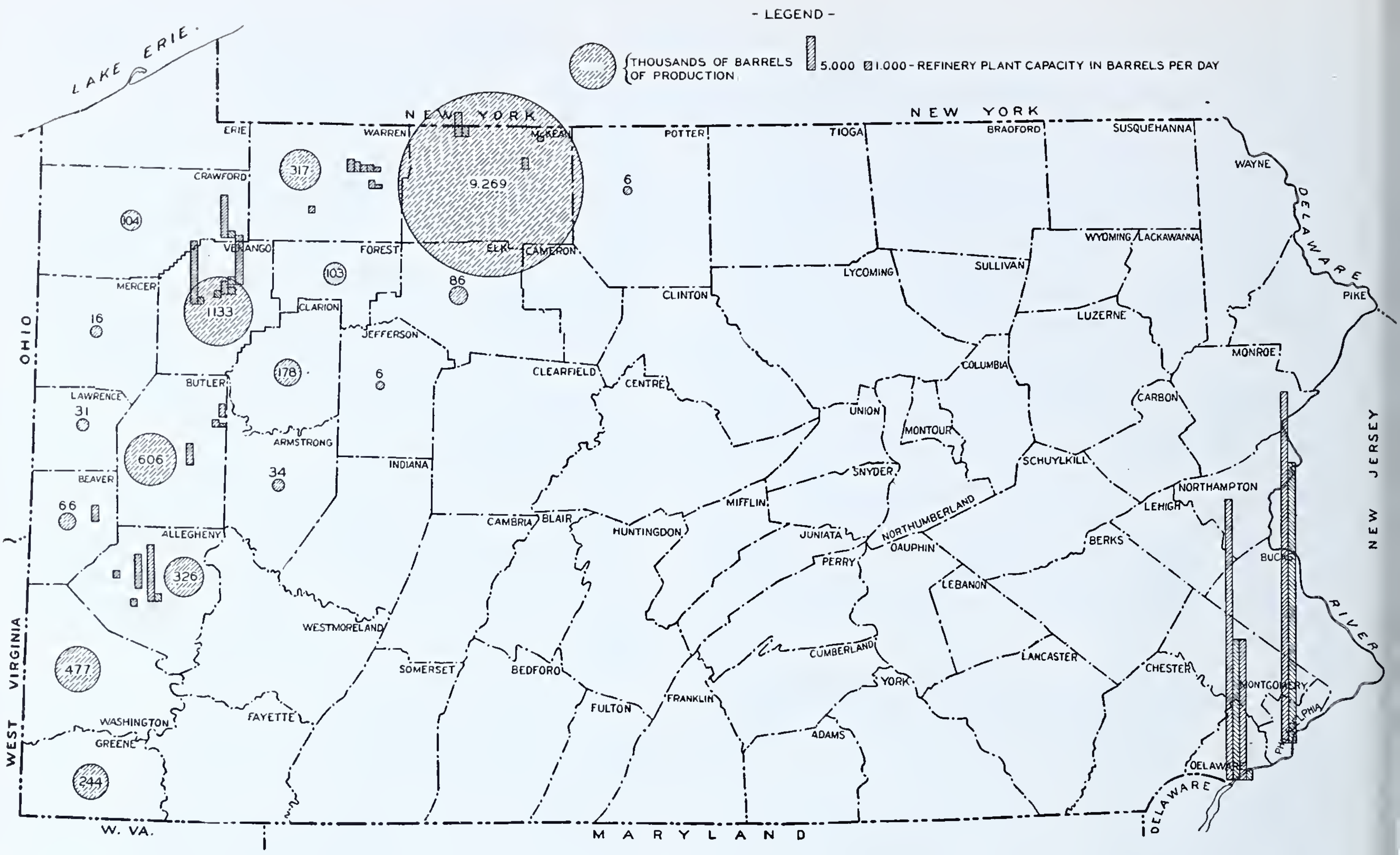


Fig. 42. Map of Pennsylvania showing petroleum production by counties and refinery capacity (data from United States Bureau of Mines).

the proportion of the United States total produced by Pennsylvania became steadily smaller. As the nation's production increased, Pennsylvania's production declined. Most of the oil obtainable by ordinary methods was gone. In 1926 Pennsylvania's production had declined to only 1 per cent by bulk and 2.2 per cent by value of the country's total, although the State's production curve had already started upward as a result of the application of secondary recovery methods. In 1931 Pennsylvania produced 1.4 per cent by bulk and 4.3 per cent by value of the United States total.

"Pennsylvania-Grade" Crude Oil

The crude oils of Pennsylvania are in general of excellent grade, being of light gravity with a paraffin base, and they are relatively free from sulphur and other impurities. They contain a high percentage of gasoline and the lighter fractions, and are easily refined. Gravity ranges from 29 degrees to over 60 degrees A. P. I., but the bulk of the oils average about 42 degrees. This average 42 degree gravity oil is called "Pennsylvania-grade" oil, and the lubricating oils made from it are considered to be unsurpassed for lubricating qualities.

In 1931, according to data of the Pennsylvania Grade Crude Oil Association, 11,815,000 barrels or 54 per cent of the total "Pennsylvania-grade" crude oil was produced in Pennsylvania, 20 per cent in West Virginia, 16 per cent in New York, and the remainder in central and eastern Ohio.

Production

The same companies or individuals commonly carry on all the operations from the initial search for oil up to the point where the crude oil is turned over to the pipe-line company. This group of operations is sometimes referred to as production or the "production end of the oil business."

Exploration

Exploration includes everything from observation of oil seepages to detailed geological work, its purpose being to select the most likely places for drilling. Little exploration preceded the drilling of the early wells in Pennsylvania, but most of the later drilling has been based upon detailed geological work.

Location of Production

Texas, California, and Oklahoma were the leaders in the production of crude oil in the United

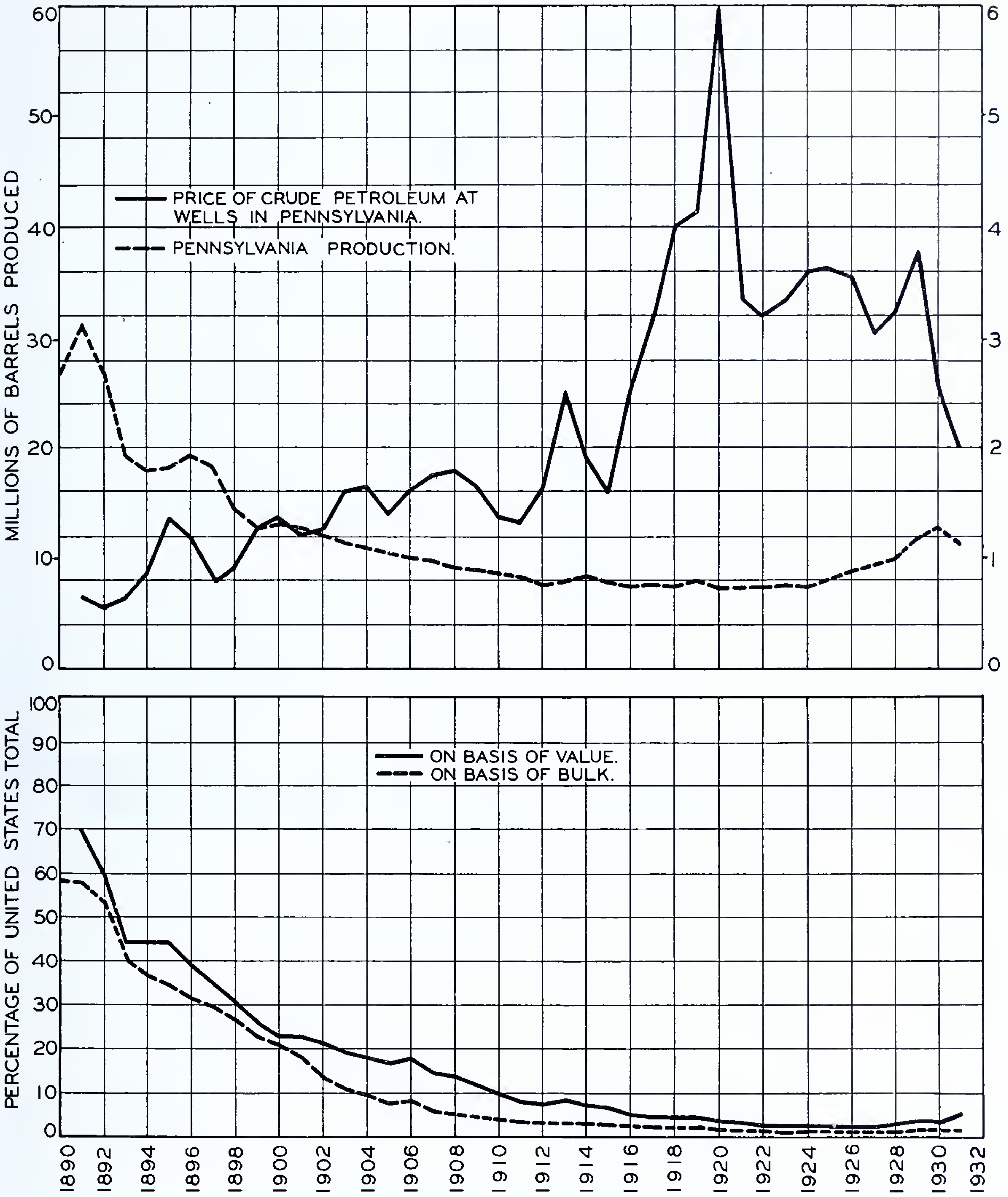


Fig. 43. Forty-year trends in the production of crude petroleum in Pennsylvania, value per barrel at wells, and Pennsylvania's proportion of the United States total. (Data from Mineral Resources of the United States and other sources.)

States in 1931, together producing about 83 per cent (by bulk) of the total. The Appalachian Field produced 3½ per cent of the country's total and Pennsylvania accounted for about one-third of the Appalachian Field's production.

In 1931 there were (according to the United States Bureau of Mines) 79,930 producing wells in Pennsylvania, more than in any other state in the Union, and 25 per cent of the United States total. On the other hand, it has been pointed out that the State had a rank of only eighth in petroleum produced and that its 12,803,000 barrels of crude petroleum were only 1.4 per cent of the United States total. It follows that the Pennsylvania wells must be small, averaging, as a matter of fact, 0.4 of a barrel per day in 1931 in contrast to 7.2 barrels for the United States as a whole.

The location of this production may be seen by reference to Figures 41 and 42. In 1930 McKean County was far in the lead, Venango was second with about one-eighth as large a production as McKean, then Butler with about half the production of Venango County, etc. The Bradford pool is by far the leading producer.

Methods of Producing Petroleum In Pennsylvania

Ordinary Drilling.

Until recent years ordinary drilling and pumping were the only methods used in Pennsylvania for getting crude oil from the ground. There have been all gradations between gas wells and wells which produce petroleum with very little gas. In some cases enough gas has occurred with the oil so that the wells flowed for a time; more frequently pumping has had to be resorted to immediately.

Depth of Wells.

The depth to oil has varied from less than 50 feet to nearly 4,000 feet, while commercial gas wells have been sunk to greater depths. Table VII gives the average depth of producing wells in Pennsylvania, not including, however, the new Oriskany sand gas fields in Tioga and Potter counties, where the depth varies from 3,800 to 5,000 feet.

TABLE VII

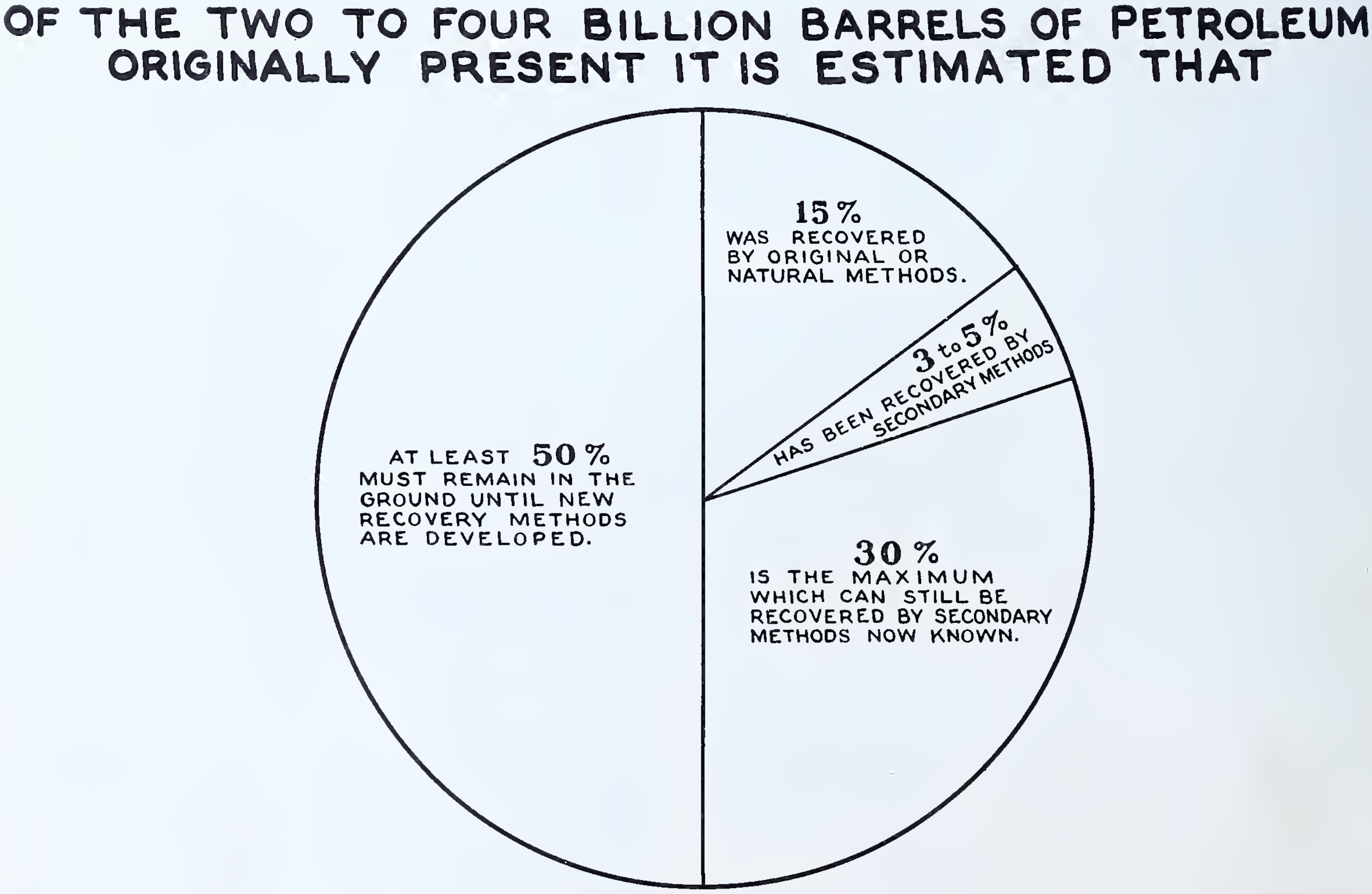
DEPTH OF PRODUCING WELLS IN THE MAJOR OIL AND GAS DISTRICTS OF PENNSYLVANIA[a]

District	Avg. depth (Ft.)
Bradford	1,230
Middle	710
Venango-Clarion	750
Butler, Armstrong	1,505
Southwest	2,175
Pennsylvania as a whole	1,344

[a] Arnold, Ralph, and Kemnitzer, William J., Petroleum in the United States and Possessions, New York, 1931, p. 88.

Secondary Methods.

In new, flush oil fields of the United States only the ordinary drilling is used. In some of the older fields, such as those of Pennsylvania, these initial methods are being followed by secondary methods designed for a more complete draining of the oil



OF THE TWO TO FOUR BILLION BARRELS OF PETROLEUM ORIGINALLY PRESENT IT IS ESTIMATED THAT

Fig. 44. The recovery of petroleum in Pennsylvania. (Based on various estimates.)

sands than was accomplished by the primary methods. It has been estimated that original methods in Pennsylvania left 80 to 85 per cent of the oil in the ground (Figure 44), and this remaining oil is the objective of the secondary methods. Among such methods in use or suggested for use in Pennsylvania are:

1. Water flooding of oil sands
2. The application of vacuum
3. Use of gas and air pressure in pools
4. Mining the sand.

Water Flooding.—Water flooding is a method of secondary recovery found to be of benefit in certain rather uniform, tight sands. In using the flooding method, water is put into oil sands which have been exhausted by ordinary pumping methods, but which are known to contain large quantities of oil. Analyses of core samples of the Bradford sand in northwestern Pennsylvania indicate that the average oil saturation of the sand is 55 per cent, in spite of the fact that the field is "exhausted" as far as ordinary methods go.[4]

In water flooding, a five spot pattern is usually followed. Four intake water wells spaced equidistant on the corners of a square are drilled, and an oil well is drilled in the center of the square. This five spot pattern is added to the original square until the required number of acres has been developed. Water is piped to each of the water intake wells through a buried pipe line system and pressure applied to the oil sand which forces the oil through the sand to the oil well in the center from which it is pumped daily.

Water flooding is now firmly established in the Bradford-Allegany fields. It has greatly increased production within recent years. In fact, these flooding operations are responsible for the flattening out, and, within the last six or eight years, the rise in Pennsylvania's production curve (Figure 43). The method has been tried in other fields in Pennsylvania, but so far has been developed on a commercial scale only in the Bradford-Allegany area, where the process may be said to have reduced itself to one of "mathematics, capital, and management".[5] It is generally successful, too, in most of the New York State fields.

Analyses of core samples not only guide the details of flood operation, but make possible a fairly close estimation of the recoverable oil as well. From such data it is possible to state that water flooding has established a reserve of approximately 600,000,000 barrels of recoverable oil in the Bradford-Allegany fields which would never have been obtained by natural methods of production.[6] It was said in 1930 that at their present rate of production a future life of 50 years seemed assured for these fields.

A special advantage of water flooding is the careful control of production which is possible. Through analyses of core samples producers know just how many acres must be drilled in order that they may obtain a certain production. By the use of delayed pumping and delayed drilling the oil production can be so regulated as to make it unnecessary for the pipe line or refinery to carry excessive stocks.

Soda ash or soap solutions. — The use of soda ash solutions in flooding operations has been the subject of experimentation, the theory being to loosen the film of oil surrounding each grain of sand, and then to flood out the released oil by the use of water. So far, this variation of the ordinary flooding has not proved of commercial importance. Field tests have been made, but the results have been negative. Where the sand contains much calcium or magnesium chloride, or where flooding comes in contact with solutions of these salts, there is likely to be a reaction resulting in the precipitation of calcium and magnesium carbonates as finely divided material that may plug the pores of the sand.

The use of solutions has been considered, too, for areas where ordinary water flooding has removed all of the oil obtainable by that method, but there has not been sufficient experimentation in the laboratory or field to prove the feasibility of this plan.

Hot water for flooding. — The use of water at higher than normal temperatures has been suggested, but thus far not applied in the field. High temperatures might be applied either in the case of plain-water flooding or flooding with solutions such as those described above. Laboratory experiments indicate that heating the water aids recovery in the case of oils whose viscosity decreases sharply with increasing temperature.

Vacuum Method. — The vacuum method has been employed for a number of years, and has resulted in increased production, or at least a speeding up of production, in some localities. The major increases in production, however, have come about through the use of other methods.

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[4] Torrey, Paul D., Bradford-Allegany's Great Future, Oil and Gas Journal, Feb. 27, 1930, p. 42.

[5] Zook, Ralph T., Production and Consumption of Pennsylvania Grade Crude Oil, Proceedings of the First Petroleum and Natural-Gas Conference, The Pennsylvania State College, Mineral Industries Experiment Station Bulletin No. 9, 1930, p. 68.

[6] Torrey, Paul D., op. cit., p. 155.

Repressuring with Air and Gas.—This method consists essentially of pumping gas or air into the oil-producing sand. The gas or compressed air moves the oil by direct pressure, and, secondly, by going into solution with the liquid under pressure near the point where the gas or air is forced in and then expanding near the producing well.

Flooding with air and with gas has been used extensively in Venango County and elsewhere south of Bradford. In the Bradford area the use of air for repressuring has not been entirely satisfactory, because of the high pressures required to obtain adequate volume input and the comparatively high operating costs. Trouble has been experienced, too, from the effect of sand wearing away the cups and valve seats, and from the fact that some of the oil produced in this way is "cut", or emulsified, and, hence, discounted by the pipeline companies. In the Venango County sands, air or gas is used extensively for increasing production.

On many properties it is reported that repressuring doubles production, and some properties report increases in production of four or five times the production by natural flow, but such increases are uncommon and there have been no reports of increases comparable to those from water flooding. It must be remembered, however, that water flooding cannot be applied everywhere. Water flooding and the application of air and of gas—each has its place, the process used depending largely upon sand conditions.

"Oil Mining". — Oil recovery by a mining operation has been suggested for old oil fields such as many of those in Pennsylvania. A cost of about 64 cents per barrel is claimed for the Ranney process of mining in contrast to costs of $1.75 up to $3.00 per barrel by water flooding.[7] The method consists of sinking two shafts, one for ventilation and the other for operation, to a point beneath the producing sand. From the operating shaft, tunnels are driven, and from these tunnels holes are drilled up into the sand and repressuring operations conducted with water, air, gas, or other propulsive agent, the oil being obtained from other wells drilled up into the sand. Or the tunnels may be driven above the sand and repressuring done by means of these with the producing holes drilled downward into the sand. Since all the oil from a considerable area can be handled through one pump there is a considerable saving in lifting costs.

It is claimed for oil mining by the Ranney process that it will recover 60 to 75 per cent of the oil remaining in the sands in contrast to a 40 per cent recovery by water-flooding in the Bradford-Allegany fields, and a recovery of 20 per cent by gas repressuring.[8] In other words, oil mining by the Ranney process might be expected to increase the efficiency of oil recovery in comparison with water-flooding by 80 per cent and over gas-repressuring by 260 per cent. Moreover, according to Torrey,[9] in a recent review of this subject, "it seems very probable that oil mining can be carried on at a satisfactory profit at an oil price which would prohibit economic production by water flooding".

Characteristics of Pennsylvania Production

The wells drilled in Pennsylvania have seldom been large as judged by the standards of many other oil-producing areas. They are noted, however, for remarkably long lives. Once a well reaches settled production, and this is usually reached promptly, it may produce a barrel or less of oil per day for 40, 50, or even more years, the price received for the oil being the principal factor in determining the limit of life of the well. Many wells, each with a very small production, now characterize the Pennsylvania fields. Four-tenths of a barrel per day is the average for producing wells in the State. All wells are "on the pump" in contrast to the flowing wells of many of the Oklahoma, Texas, and California fields.

Cost of Production

Drilling costs in the Pennsylvania oil fields were never large as compared with those of the Mid-Continent and other fields, chiefly because most of the wells drilled in Pennsylvania as in other parts of the Appalachian Field have not been very deep nor expensive to equip.

In Pennsylvania there are the special cost questions to which secondary methods give rise. Ranney[10] estimates the total cost of producing oil by water flooding in the Bradford field (including the cost of acreage) at from $1.75 to $3.00 per barrel. The cost of producing oil naturally or by means of an air drive or gas drive, he goes on to say, is extremely difficult to ascertain, being estimated variously at from $2.00 to $4.00 per barrel, few producers claiming that their total is as low as $1.50 a barrel. For oil mining, as has been pointed out, a cost of less than $1.00 per barrel is claimed, though no operations of this sort have as yet been carried out in Pennsylvania.

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[7] Ranney, Leo, Oil Mining for the Pennsylvania Fields, Proceedings of Engineers' Society of Western Pennsylvania, Vol. 47, 1931, pp. 316 and 331.

[8] Torrey, Paul D., The Possibilities of Mining for Petroleum in the Appalachian Oil Fields, Proceedings of the First Petroleum and Natural-Gas Conference, The Pennsylvania State College, Mineral Industries Experiment Station Bulletin No. 9, 1930, p. 23.

[9] Torrey, Paul D., op. cit., p. 24.

[10] Ranney, Leo, op. cit., p. 316.

Wastes In Production

A great deal of petroleum was wasted in one way or another during the early days of production in Pennsylvania. With diminution of supply and the adoption of secondary methods, waste has been much reduced though by no means eliminated.

Natural gas accompanying oil was long allowed to pass off into the air. This was not only a waste of gas, but also an indirect waste of oil, since gas supplies energy to move the oil and increases its fluidity and hence the percentage recovery.

Frequently because of the presence of small leases many wells have been drilled when a few could have drained a given pool. Overdrilling is, however, largely a thing of the past in Pennsylvania (except in so far as differences in well-spacing patterns are concerned) as secondary recovery requires a measured scientific procedure.

A great deal of oil was left by the original recovery methods. Several years ago Melcher[11] estimated the average recovery in Eastern fields at approximately 10 per cent of the original oil content. Although this may be low, it is probable that the correct figure is less than 20 per cent (Figure 44). Some of the oil thus left is now being recovered by secondary methods. It has been pointed out that oil mining by the Ranney process may mean a more efficient oil recovery than is possible by any of the other secondary methods now in use. Even this method, however, cannot be expected to secure all of the oil. It is also possible that improved methods of flooding with water solutions may be developed.

Other losses have been in the past, and are still to some extent, occasioned by failure to properly exclude water from sands, by evaporation and seepage, fire, accidents of various sorts, failure to provide storage for oil produced in excess of market needs, and by other improper methods of lease operation.

Purchase of Crude Oil

"Crude oil is purchased in two ways: One is that the oil is sold when run. In this case it becomes the property of the buyer as soon as it enters the pipe-line system, and is paid for three times per month, with the privilege to the producer of calling on the buyer any day for settlement of the crude held to his credit. The second method is known as credit-balance system which permits a producer to run oil into the pipe-line and sell it later. If he does not like the present market he permits his balance to grow until he desires to sell and pays the pipe-line a charge for storage. More than 99 per cent of the Bradford and Allegany crude is run on direct sale, but in a number of the producing areas the majority of the crude is run on the credit-balance system".[12]

The Uses of Petroleum

Of the oil produced in the United States, about two-fifths is consumed as gasoline, one-twelfth as kerosene, one-twenty-fifth as lubricants, one-fiftieth as gas-oil used in artificial gas manufacture, and the remainder (or nearly one-half) is used as fuel or gas oil in competition with coal for general purposes, including steamship and locomotive fuel, house-heating, etc.

The proportions for "Pennsylvania-grade" crude oil are somewhat different. "Pennsylvania-grade" crude has always been valued particularly for the lubricants which can be made from it. Hence, lubricating oils are of much greater relative importance in the products of refineries using principally "Pennsylvania-grade" crude than is true in all United States refineries considered together.

The present discussion has to do with production, and from the producer's point of view all but a very small amount of the crude oil produced is sold to the refineries. The uses to which it is then put will be discussed further under refining.

Markets For Crude Petroleum

The markets for crude petroleum are the refineries. "Pennsylvania-grade" crude oil is sold to refineries in western Pennsylvania, and, to a smaller extent, to refineries on the Atlantic Coast.

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[11] Melcher, A. F., as quoted by Ranney, George, op. cit., p. 328.

[12] Hanks, George J., The Collection, Transportation, and Distribution of Pennsylvania Grade Crude Oil, in Proceedings of the First Petroleum and Natural-Gas Conference, The Pennsylvania State College, Mineral Industries Experiment Station Bulletin No. 9, 1930, p. 63.

Crude oil from other states is marketed in Pennsylvania in large quantities. "Pennsylvania-grade" crude oil moves, to some extent, from West Virginia and other parts of the Appalachian Field to refineries in western Pennsylvania. Mid-Continent crude makes the long trip by pipe line to western Pennsylvania refineries, and on across Pennsylvania and adjacent states to the Atlantic Coast refineries including those in southeastern Pennsylvania. Gulf Coast crude moves by tanker to the refineries of southeastern Pennsylvania, and also, to a much smaller extent, by pipe line from southeastern Pennsylvania to western Pennsylvania refineries. In addition to these domestic movements, crude oil from foreign countries, particularly from Venezuela, reaches southeastern Pennsylvania by tanker.

Prices of "Pennsylvania-Grade" Crude Petroleum

The prices of "Pennsylvania-grade" crude oil were until recently controlled by the posted price of the Seep Purchasing Agency, a branch of the South Penn Oil Company, while most other purchasers followed the Seep Agency prices. Next to the Seep Agency, the Tidewater Oil Company and the Vacuum Oil Company were important purchasers. The Seep Purchasing Agency has now passed out of existence.

Prices of crude oil in Pennsylvania are in general closely related to the price of "bright" (lubricant) stocks, since the chief value of Pennsylvania's crude oil is for making lubricants. The average price per barrel paid for crude petroleum at the wells in 1931 was $1.98 for Pennsylvania as compared with an average of $0.65 for the United States as a whole. In this price Pennsylvania was outranked by New York (average price $2.02) and closely followed by West Virginia (average price $1.58). Of the states with appreciable production, these three are the only ones in which the average price exceeded $1.25. The relatively high prices which prevail in the Appalachian Field reflect the good location of the field with respect to markets, but, even more, the premium which "Pennsylvania-grade" crude oil commands.

Although the average price paid for "Pennsylvania-grade" crude in 1931 was under $2.00, the price still represented a considerable premium over most other crude petroleum. Extensive advertising has played its part, and people ask for "Pennsylvania-grade" products, but there is every indication that producers and refiners of "Pennsylvania-grade" crude are going to be forced to face severe competition in the future—competition which may ultimately force the development of more economical methods of refining and producing.

An important feature of the marketing of "Pennsylvania-grade" crude oil was the formation, in 1923, of the Pennsylvania Grade Crude Oil Association consisting of both producers and refiners, to advertise "Pennsylvania-grade" crude oil and the products made therefrom.

Overproduction

The larger phases of overproduction which have so long irked the petroleum industry have been described many times. In its larger aspects overproduction is a problem with which the new flush fields are most concerned. The petroleum industry of the United States passed through a period of the formation of trusts; then these were dissolved, or very largely so, and a period of unrestricted competition inaugurated. It is this unrestricted competition which has been largely responsible for the overproduction and consequent waste of recent years. Combinations or at least agreements have been fostered within the last few years in an attempt to check the menace of oversupply.

All this, though nation-wide or even world-wide in scope, finds its echoes in Pennsylvania. Though mad rushes of drilling belong to a past epoch in Pennsylvania petroleum history, yet the Pennsylvania fields are affected by the overproduction. Low prices and a too great abundance of oil have cut into the markets for "Pennsylvania-grade" crude. Lubricating oils are being made from low-grade crude oils under the impetus of lack of other markets for the latter material. The demand for "Pennsylvania-grade" crude has been kept up, in part through advertising, but low prices and the necessity for pro-ration have affected the Pennsylvania fields, though not in the same degree that they have some of the "flush" fields.

Pro-ration

"During April, 1930, it was realized that the production in the Bradford and Allegany Fields was increasing more rapidly than the market could absorb it, and some correction must be made. On the basis of 72,000 barrels consumption and 80.000 barrels production of Pennsylvania Grade Oil, with the Bradford and Allegany Fields producing a total of 43,000 barrels daily, it was felt that a cut of 20 per cent based on April fig-

> ures would be sufficient to bring supply and demand in balance. This was accomplished during June when these two fields decreased their production approximately 8,000 barrels daily. However, consumption dropped from 72,000 barrels in April to 62 000 barrels in May and 63,000 barrels in June, and it was realized that further steps must be taken. Beginning July 1, the Bradford and Allegany Fields agreed to curtail their production 50 per cent based on April figures, and the districts south of Bradford were asked to curtail their production 30 per cent. This resulted in 62,000 barrels production for the month of July against a consumption of 61,000 barrels. This rate of curtailment with active cooperation of all fields continued until the latter part of September..............................''[13]

Pro-ration was lifted in the fall of 1931 with the understanding that producers would maintain a balance between production and consumption. In January, 1932, however, the Eureka Pipe Line Company cut their runs 10 per cent, indicating a resumption of a certain amount of pro-ration.

Pro-ration brought some difficult problems to the Bradford and Allegany districts where flooding is in use. Production costs had been carefully calculated, and when the rate of oil production was decreased that meant a higher cost per barrel. In many cases continuation of profitable operation was dependent upon either reducing operating expenses or increasing ultimate recovery.

Conservation

Conservational practices are much more widely used in Pennsylvania than is the average for the United States. Secondary recovery is conservational, since it represents an increased recovery in contrast to waste of a considerable amount of oil by stopping with the ordinary drilling and pumping methods. Conservational, too, is the continuation of production while a well produces only a fraction of a barrel. This would be impossible in the Mid-Continent Field, chiefly because the oil does not command as high a price in its area of production as does ''Pennsylvania-grade'' crude in Pennsylvania.

Tariff on Imported Crude Oil

A tariff upon ''cheap foreign oil'' has been demanded by the producers in Pennsylvania and other states, who blame many of the recent troubles of the petroleum industry upon such imports, and contend that not only petroleum producers but state and federal governments as well face reduced revenues from the invasion of this foreign oil. In response to this demand, a bill was passed in the last session of the United States Congress (1932) providing for a 21 cents per barrel tariff on crude petroleum and fuel oils. Other provisions of the bill included a 2½ cent tariff on gasoline, 4 cents per gallon on lubricating oils, 1 cent per pound on paraffin, and 10 cents per 100 pounds on asphalt and bitumen.

Aligned with domestic producers in favoring this measure were the producers of coal and other fuels competitive with fuel oil, since it is to their interest to keep cheap fuel oil off the market. Opposed to the tariff were those refinery interests which depend in part upon foreign crude, and many consumers who reasoned that the cost of the tariff would eventually be paid by them through higher retail prices of refinery products.

The Future of Petroleum Production In Pennsylvania

Arnold and Kemnitzer[14] classify the land of Pennsylvania on the basis of oil and gas possibilities as follows:

TABLE VIII

CLASSIFICATION OF LAND FOR OIL AND GAS

Classification	Area in sq. mi.	Pct. of Tl. Area	Location
Impossible	2,670	5.9	Areas of igneous and highly metamorphosed rocks in southeastern Pennsylvania.
Unfavorable	20,542	45.5	Most of Pennsylvania east of a line running northeast from southeastern Fayette County through northwestern Centre County to the northeast corner of Susquehanna County.
Prospective	19,070	42.3	Approximately the northwest half of Pennsylvania, or that part west of the line described under "Unfavorable".
Proved	2,844[a]	6.3	Irregular belt 25-120 miles wide extending northeast - southwest across western Pennsylvania (see Fig. 41).
Total area of Pennsylvania	45,126[b]	100.0	

[a]Oil area, 1,358 square miles; gas area, 1,486 square miles.

[b]Water area included, 294 square miles.

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[13] Zook, Ralph T., op. cit., p. 67.

[14] Arnold, Ralph, and Kemnitzer, William J., op. cit., p. 93.

It may be seen from the foregoing table that 2,844 square miles, or 13 per cent of the original prospective area, has proved productive. About half of this, or 6.2 per cent, has been productive of oil; the other 6.8 per cent, of gas only. However, future discoveries in the 19,070 square miles of prospective area are expected to be insignificant, and it is not believed that the productive area will ever reach 16.5 per cent of the original prospective area, or 7 per cent of the area of the State. The petroleum area of the State is estimated as 80 per cent developed. In proved areas, deeper drilling may develop some new producing sands, but few commercial accumulations are expected beneath present developed sands.

Under present conditions and methods of production, it is thought that an average annual production of 10,000,000 to 12,000,000 barrels may be maintained for 50 or 60 years. If demand increases and prices rise, this annual production may be greatly increased, since the water flooding methods of the Bradford-Allegany district would permit a considerable extension of production at any time. Such speeding up of production, if it occurs, will shorten the life of the industry in Pennsylvania. On the other hand, it may be found possible to apply water flooding commercially in other Pennsylvania fields, or improved technology may make possible, through mining or other methods, a much greater recovery of petroleum than is now anticipated.

The Last Stage of Production

As production is defined here it includes movement of the oil by pipe line from the wells to the producers' run tanks. Here the petroleum awaits turning into the lines of the pipe-line company.

Transportation

''Transportation'', as here used, refers to the movement of crude petroleum from the producers' tanks to the refinery or other consumer.

Petroleum is transported from fields to refining centers by tank car, tank steamer, and pipe lines. Only the last means of conveyance, the pipe line, is used to move crude oil produced in Pennsylvania; but tank steamers enter into the refining picture, since they bring Gulf Coast and foreign crude oil to southeastern Pennsylvania for refining there, and for movement by pipe line to the refineries of western Pennsylvania. Tank cars are not used in transporting crude oil in the State, since pipe-line transportation is much more economical.

Pipe Lines

The following discussion of the part played by pipe lines in Pennsylvania's petroleum industry was contributed by Mr. George J. Hanks of the Tide-Water Oil Company:

''Eight years elapsed after Colonel Drake drilled the first oil well in 1859 before crude was transported by pipe line. Today, pipe lines play a very important part in making petroleum and its products available to the world. Their efficient operation results in low cost for movement of great volume.

''There are two classes of pipe lines. The first is a refinery facility, since the system is owned by a local refinery and functions as an integral part of the owning company's operation. Such systems may be quite comprehensive and handle a large amount of business, but generally deliver to one refinery only. The second class acts solely as a common carrier, being subject to the provisions of the Interstate Commerce Commission by virtue of the so-called Hepburn Amendment of 1906 if they perform inter-state business, and in Pennsylvania such carriers are also subject to the jurisdiction of the Pennsylvania Public Service Commission as refers to intra-state business. This class of carriers generally delivers to more than one refinery; and, as a rule, not only operates a gathering system, but many miles of trunk line to transport crude from the area in which it is produced to refiners in other localities.

''The pipe line organization is comparable to that of a railroad and it has been termed 'underground railway system'. It requires trunk and branch or gathering lines, terminals, storage yards, stations, dispatchers, and communicating systems. It is essential that a common carrier pipe line maintain capacity in excess of the daily average production usually handled, so as to enable it to meet the peak requirements of the refineries served, through ability to draw on stocks of tanked crude in addition to handling daily production from producers' tanks. The areas producing Pennsylvania grade are particularly reinforced through the present capacity of the common carrier lines now serving them. For example, the Bradford Field now producing under 28,000 barrels daily has, in addition to refinery facility capacity of 12,000 barrels, common carrier capacity of 42,000 barrels daily, or a total approximately double the present production. The common carrier lines have ability to divert from Bradford 16,000 barrels daily eastward through Tide-Water's system to New York harbor; 2,000 barrels daily northward through New York Transit system to Olean; and 24,000 barrels daily southward through National Transit and Tide-Water's system to Clarendon, Warren, Titusville, Rouseville, Oil City, and other Southern Pennsylvania refinery locations as far south as Pittsburgh. The Southwestern producing areas in Pennsylvania are served through the system of the Southern Pipe Line Company with capacity of 16,000 barrels daily for transportation to either Philadelphia or New York harbors. In addition to this net work of trunk lines across both the Northern and the Southern sections of Pennsylvania, there is a complete system of large size lines connecting the Northwestern and Southwestern producing areas in Pennsylvania with complete ability to move crude North or South to meet the demands of the various refiners. In the Southern portion these lines extend into Southeastern Ohio and West Virginia, and serve the areas in those states producing Pennsylvania crude, through complete interconnected systems.

"Other grades of crude are also transported through Pennsylvania. Various coastal grades received by tankers at Philadelphia harbor are pumped via National Transit system through Central Pennsylvania to refineries at Franklin and Pittsburgh. Mid-Continent grades are delivered through Northwestern Pennsylvania by the systems of the Northern Pipe Line and Tide-Water through to Olean and Buffalo, N. Y., and by Southwestern Pennsylvania Pipe Line Company to Pittsburgh. The chief refining centers in Pennsylvania can be supplied by pipe line with practically any grade crude produced East of the Rocky Mountains that various refineries may elect to use and on a very attractive delivered cost basis comparable with the cost resulting from tank car shipments. It may be accepted as certain that the pipe line industry in Pennsylvania will continue to maintain their investment so as to efficiently and ably serve the refineries with their crude products."

Losses In Transportation

A certain amount of loss in transportation through escape of gas and light products of the crude is unavoidable, and a transportation system in which the loss is under two per cent is considered efficient.

Petroleum Refining

Though petroleum refining is predominantly a chemical industry, it is unquestionably, also, the processing of a raw mineral product. Hence, it is included in this report.

If crude petroleum is exposed to the air it gradually thickens. The first product given off is natural gas; then liquid components evaporate in the order of their lightness; and the final residue is composed largely of either paraffin wax or asphalt. Petroleum is thus seen to be a mixture of different liquids holding in solution also natural gas and solid substances. Refining separates these various substances.

Petroleum refining in the United States as a whole results, in order of value, in gasoline; fuel oils; lubricating oils; illuminating oils; naptha, benzine, and tops; greases; and a variety of minor products—but this order of importance does not hold good in Pennsylvania, where lubricating oils are over twice as valuable as the fuel oils produced (Figure 45).

The Refining Process

"Petroleum is a mixture of many hydrocarbons, which boil and vaporize at different temperatures. When a quantity is introduced into a still and subjected to gradually increasing heat, the lightest elements rise and escape as vapor. These vapors are then condensed. The lightest to come off are the napthas and gasoline; then, at a somewhat higher temperature, kerosene vaporizes, flows away, and is in turn condensed. Next come the still heavier oils, which ultimately become lubricants, paraffin, and other products. In the refining of asphaltic crude the asphalt will not distil over and is left as a residue in the still and is then recovered for commercial use. Such is a simple statement of the bare elements in the process commonly known as 'straight' refining."[15]

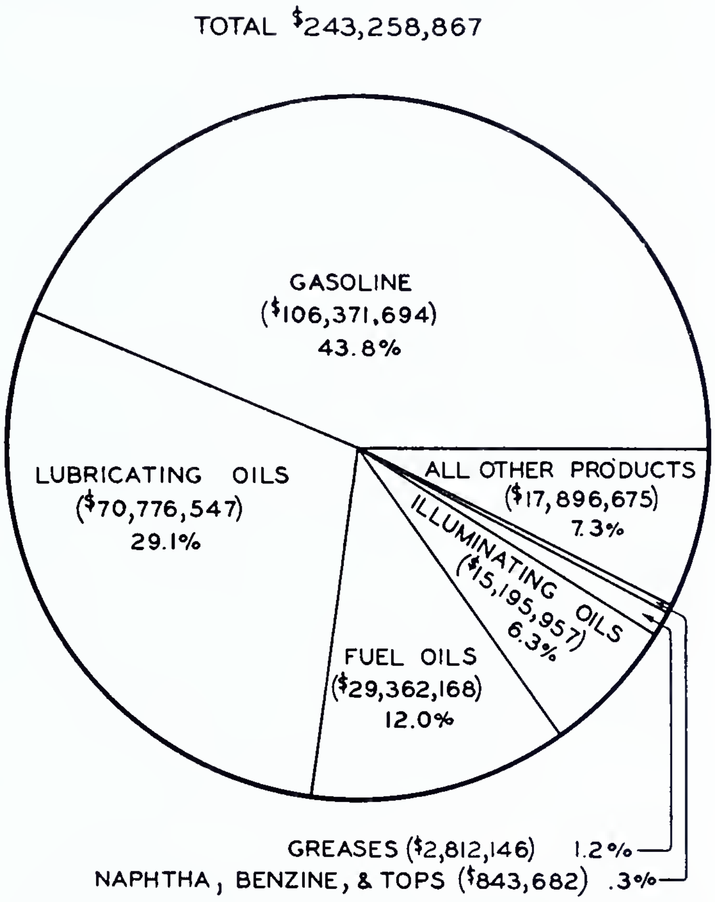

Fig. 45. Value of products of petroleum refined in Pennsylvania, 1929. (Based on Census data.)

Straight-run refining is now giving way to cracking, a process by which the gasoline fraction resulting from refining is increased, and the less marketable fractions decreased. By this process much more gasoline is obtained in proportion to the crude oil treated than by straight-run refining. The extent of cracking operations depends somewhat upon the price of gasoline, being more extensive when gasoline prices are high. There is a steady natural growth in the use of the process, however, resulting from the steady expansion in equipment. It is mostly the intermediate distillates which are cracked, but to a lesser extent the heavier fuel oils are so treated. Therefore, it is said that any further development of cracking would cut much more heavily into the percentage of fuel oil now produced than has cracking development to date.

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[15] Voskuil, Walter H., Minerals in Modern Industry, 1930, p. 113.

Commercial testing of a new process called hydrogenation[16] is under way. In this process the heat and pressure are increased and hydrogen is introduced into the stills, and furnishes material for combination with the oil constituents to produce much larger percentages of the lighter oils. By this method practically all of the crude oil could be turned into lighter products.

The Materials Used In the Industry

Seventy-two million four hundred eighty-one thousand eight hundred twenty-four barrels of crude petroleum were used in the petroleum refining industry in Pennsylvania in 1929 according to the United States Census. The fact that this is over six times as much crude petroleum as was produced in the State indicates the degree to which the refining industry of Pennsylvania, though originally based upon local petroleum, now goes far afield for its basic material. The crude used is reported to have cost $151,974,753.

The Pennsylvania industry also used 7,588 342 barrels of partially refined oils, waxes, tops, etc., which cost $24,377,119; six hundred fifty-two thousand eight hundred three barrels of natural gasoline (for blending) which cost $2,676,981; ninety-nine thousand ninety short tons of sulphuric acid, 67,237 tons being purchased and produced in the plants at a cost of $1,068,053 and 31,853 tons reclaimed and used at a cost of $301,959; fifteen thousand six hundred seventy-nine tons of caustic soda purchased at a cost of $820,252; and sundry smaller items.

Importance

The "value added by manufacture" for petroleum refining in Pennsylvania in 1929 was $48,215,658, almost twice as much as the comparable figure for manufactured gas and $10.000,000 greater than the "value added for manufacture" for coke and its by-products in the State. As pointed out on an earlier page, Pennsylvania with eight per cent of the United States total "value added by manufacture" ranked fourth among the states in petroleum refining, being outranked by California, New Jersey, and Texas. Peculiarly enough, while the "value added by manufacture" of the State's petroleum-refining industry has shown a net gain within recent years (Figure 46)[17] the State has been losing in percentage of the United States total. Extension of the petroleum-refining industry into new areas in the United States has doubtless been responsible for most of this decline.

Transportation of Refinery Products

Delivery of refinery products to their consumers constitutes a special form of transportation. Gasoline moves principally by tank car and truck, though one pipe line carries gasoline from Southeastern Pennsylvania across the State to Ohio. Gas oil, fuel oil, and lubricants are shipped in barrels, in tank cars, or by truck; while kerosene moves by tank car and trucks.

Products of the Industry

The products of Pennsylvania's petroleum refining industry were valued at $243,258,869 in 1929, the proportions of the several products by value being as shown in Figure 45. As pointed out earlier, the chief difference between these proportions and those for the United States as a whole is the much larger percentage of total value represented by lubricating oils in Pennsylvania—29.1 per cent as compared with about 11.5 per cent—and the proportionally smaller percentage represented by gasoline and fuel oil.

Two Groups of Refineries In Pennsylvania

Petroleum refining in Pennsylvania is carried on by two distinct and widely separated groups of refineries.

The Western Group.

One group is located in western Pennsylvania. On January 1, 1931, there were about thirty-one of these western Pennsylvania refineries in operation, spread over seven counties (Figure 42).

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[16] The process is applicable also to coal. See under "Liquefaction" in chapter on coal processing.

[17] In the curve showing Pennsylvania's proportion of the United States total, data for establishments with products under $5,000 in value were included for 1919 and prior years but not for 1921 and subsequent years. The discrepancy thus introduced is very small.

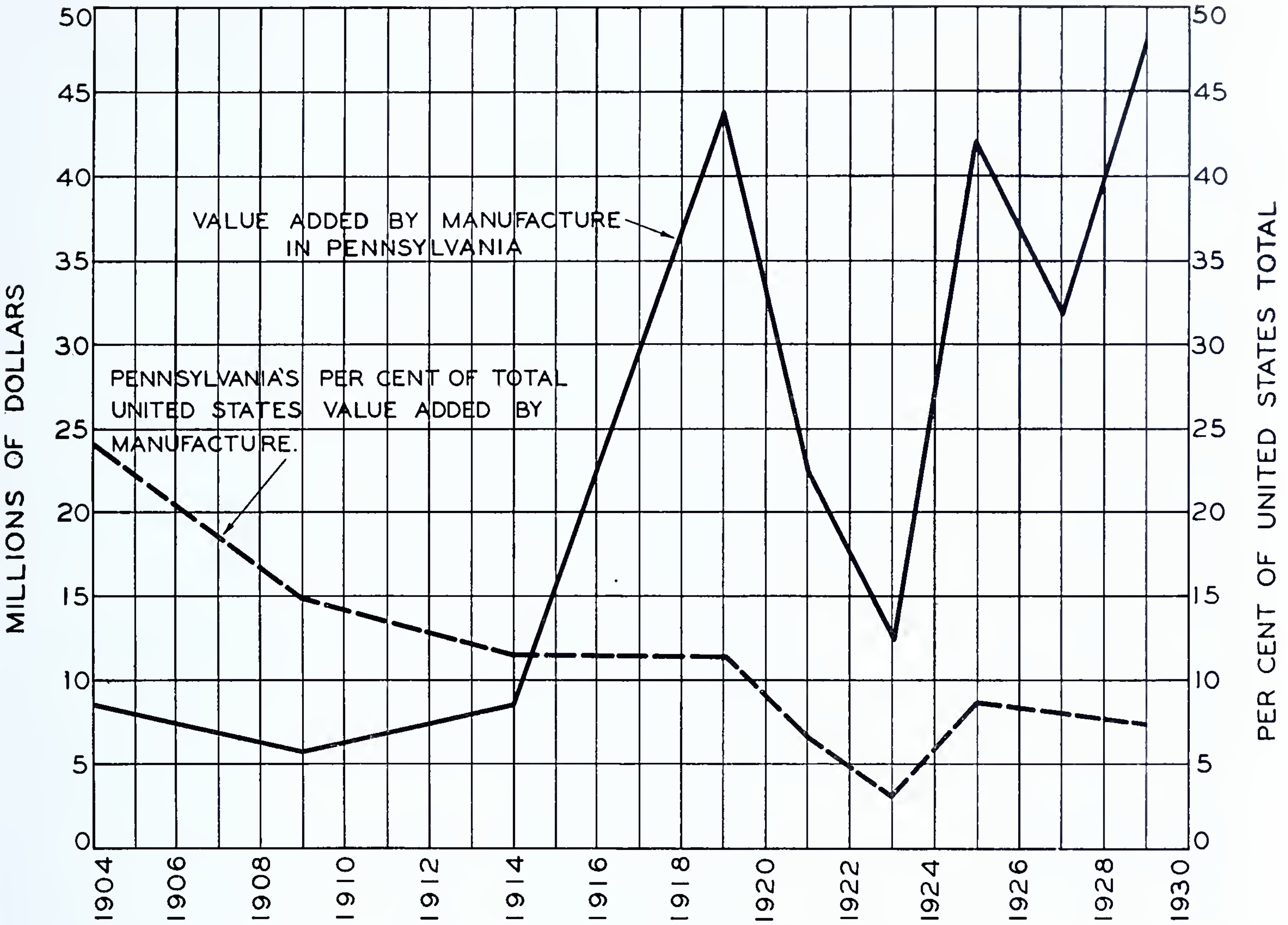

Fig. 46. Approximate trends in Pennsylvania's petroleum-refining industry. (Based on data from United States Census.)

Venango and Allegheny counties had the largest total refinery capacity.

The refineries of this group are small as compared with the average for southeastern Pennsylvania. One refinery, located at Franklin, has a capacity of 9,000 barrels per day, but this is the largest, and the average is only a little over 2,000. The total capacity of this western group is about 72,000 barrels per day.

Fuels Used. — The Appalachian refinery district to which the western Pennsylvania refineries belong is the only district in which coal supplies more heat units than fuel oil in the distillation of petroleum. Also, the heat requirement per barrel of crude processed is more than that of any other district, and nearly double the average for the rest of the country. This latter situation is due primarily to the fact that the Appalachian refineries are nearly all "complete" plants which process their crude through the lubricating-wax stage, as compared with topping plants which merely skim the crude.

Source of Crude.—The western Pennsylvania refineries were originally closely identified with the petroleum-producing industry of the State. They developed in an oil-producing region to refine locally-produced petroleum. Now, in addition to petroleum produced in western Pennsylvania, crude comes from adjacent states, from the Mid-Continent Field, and, by pipe line, from the Atlantic Coast.

It must not be thought that all western Pennsylvania refineries use petroleum from all the sources mentioned. Many of the refineries are small and use only locally-produced petroleum. It is more often the larger refineries which supplement supplies of "Pennsylvania-grade" crude with crude from greater distances. "Pennsylvania-grade" oil is rich in lubricants compared to the gasoline content. The average sale of gasoline through service stations in the United States is twenty-two gallons per gallon of lubricating oil, and it is necessary to augment the supply of gasoline made from "Pennsylvania-grade" oil with gasoline made from other crudes.

Products Resulting.—Since western Pennsylvania refineries use predominantly "Pennsylvania-grade" crude oil, and since this crude is the lubricants made from "Pennsylvania-grade" crude oil were used in the automotive industry they would have lubricated at a conservative estimate 60 per cent of the cars in use during 1931. The high relative importance of lubricants in western Pennsylvania is still more strikingly brought out when the proportions of the several products by value are compared, and is reflected in a high relative importance of lubricants for the State as a whole (Figure 45).

The gasoline made from "Pennsylvania-grade" crude has not, in the past, enjoyed a reputation comparable to the lubricants. Recently, methods have been developed by which high-grade gasoline is made from this crude; but the necessary plant represents too large an investment for some of the smaller refineries which continue to turn out an inferior grade of gasoline, thereby lowering the reputation of all gasoline made from "Pennsylvania-grade" crude. An obvious remedy for this situation is for the smaller refineries to combine to the end of building properly-equipped plants.

The Eastern Group.

The six refineries located in southeastern Pennsylvania have a combined capacity of about 171,000 barrels per day, the largest having a daily capacity of 50,000 barrels. The combined capacity given is nearly two and one-half times the total of the thirty-one plants of western Pennsylvania. It is clear, therefore, that the southeastern Pennsylvania industry is characterized by much larger plants, though they are fewer in number.

Source of Crude.—Crude oil for these southeastern plants comes dominantly from the Gulf Coast and from foreign ports by tanker, but they also get some crude from the Appalachian Field, the Illinois Field, and even from the Mid-Continent Field by pipe line.

Fuels Used. — The primary fuel used in the Atlantic Coast refineries, to which those of southeastern Pennsylvania belong, is oil. A small amount of coal is used, but use of this fuel has been declining rapidly. The use of "refinery" or "still" gas showed a material gain in this district in 1929.

Products Resulting. — The chief differences between the products of the Atlantic Coast refineries and those of the Appalachian Field is that kerosene, lubricants, and wax are considerably less important among the products of the Atlantic Coast plants than among those of the Appalachian Field, while fuel oil, gas oil, and asphalt are of considerably greater relative importance (Figure 47).

Competitive Position of the Products Of Petroleum Refining

Though of course the various refineries compete among themselves, only one of the products of petroleum refining competes seriously with the products of other Pennsylvania mineral industries. This product is fuel oil, which competes with anthracite, bituminous coal, natural and manufactured gas, and coke.

Fuel oil competes most seriously with Pennsylvania's other fuel products in the Middle Atlantic States, particularly along the Atlantic Seaboard. There the presence of refineries makes fuel oil readily accessible. Bituminous coal is handicapped by a considerable freight charge, while anthracite, a high-cost fuel where mined, has had this cost added to appreciably in its trip from the anthracite fields. It is not surprising that coal operators look with favor upon a tariff upon imported oil, since such imports add to the fuel oil available in this debated region.

After Petroleum, What?

With the constant plague of overproduction hampering the petroleum industry, we are likely to lose sight of the fact that the petroleum supply of the world is being used up at a very rapid rate. Yet petroleum products are today practically basic necessities. They are so intimately interwoven with the industrial, commercial, and social fabric of the nation that it is difficult to see how we could dispense with them.

While the "Pennsylvania-grade" crude oil production for 1931 was only about 2.6 per cent of the nation's total, this crude is the premier source of high-grade lubricating oil, and is of increasing importance in the automotive field of lubrication. Previous to 1930, major marketers of lubricating oils, while admitting the superiority of lubricants made from Pennsylvania crude, hesitated to enter this market on account of the small known reserves of "Pennsylvania-grade" crude oil. This condition has been completely changed through the application of secondary recovery methods by water flooding in the Bradford-Allegany fields, and the marketers need no longer fear a shortage of lubricants made from this grade of crude. It is said that before the year 1933 is ended it will be possible to purchase Pennsylvania lubricating oil in almost every filling station in the United States.

The Mid-Continent Field and California now account for the bulk of the nation's oil production. A few years ago exhaustion of the petroleum resources of the United States seemed imminent, but further exploration has made it seem probable that the country's reserves are much greater than was formerly believed. Nevertheless, petroleum is irreplaceable and the end will come eventually. How then shall we satisfy our growing demands for petroleum products?

Of all the petroleum products the lubricants are the most indispensable, although their bulk is comparatively small. The amount of motor fuel used is very much greater, but methods are now known for increasing the yield of motor fuel from a given quantity of petroleum and of obtaining a satisfactory motor fuel from other sources. Advancement of the cracking process will increase more and more the gasoline production from a given bulk of crude. Hydrogenation will probably make possible the turning of a much larger proportion of crude oil into lighter products or lubricants than is now possible. Imports will increase. But all these measures will simply defer the inevitable.

Ultimately, motor fuel must be obtained from other sources than petroleum, or at least other sources must supplement the supply from petroleum. Oil shale has been prominently mentioned as a possibility. Such shale of high grade is particularly abundant in Colorado, Utah, and Wyoming, but there are extensive deposits in eastern United States as well. The reserves of oil shale in the United States are enormous. As petroleum production declines, prices will rise until oil-shale treating plants can work at a profit.

Bituminous coal and lignite, through low-temperature carbonization or liquefaction, may become sources of substitutes for petroleum products as the prices of the latter rise. Ordinary by-product coking has already made large amounts of coal-tar distillation products available, and some of these have been used as petroleum substitutes. The light distillates, such as benzol, are used as a substitute for gasoline, and the heavier distillate, or tar, as a substitute for fuel oil.

Finally, there are several agricultural products (such as grain alcohol and vegetable oils) which have been employed or proposed as substitutes for gasoline in the operation of motor engines.

Thus, though prices for motor fuel and the other petroleum products may rise, it seems probable that new technology and substitution will solve the problems of the future.

VII

THE NATURAL GAS INDUSTRY

Introduction

Nature endowed the United States with a large supply of natural gaseous fuel, but this supply was by no means evenly distributed. Large amounts were originally present in the Appalachian Plateau of western Pennsylvania, West Virginia, Ohio, and western New York; in several areas between the Appalachian Plateau and the Mississippi River; in the Mid-Continent and Gulf Coast fields of Oklahoma, Kansas, and Texas; in the Rocky Mountain districts; in California; and in a number of other scattered areas. Since long-distance piping of natural gas has not been considered feasible in the past, some localities, too often those with small local demand for gas, have had abundant supplies; while others, such as New England, where the demand for such a fuel is great, have never enjoyed a supply of natural gas. Local abundance, often in areas of sparse population, has meant low prices, and hence, frequently, the waste of large amounts of gas. Such waste has been particularly common in areas where petroleum occurred with the natural gas. In such areas much of the gas was allowed to pass off into the air in the mad rush for oil. The abundance and cheapness of natural gas have often caused the public to overlook the waste of this valuable natural resource. Thus, where natural gas could be obtained at all, there has been a general lack of appreciation of this fuel, which, in reality, has a heat value (averaging 868 to 1027 B. t. u. per cubic foot) which is about twice that of average manufactured gas, coupled with all the other advantages of a gaseous fuel.

Production of natural gas in the United States has been steadily increasing, but this has been due, chiefly, to gains by the Mid-Continent and California fields. In eastern United States, on the whole, natural gas production has been declining. This is true of Pennsylvania where, despite temporary spurts in production due to new finds, there has been a fairly steady decrease within recent years (Figure 48). It is not surprising, therefore, to find in Pennsylvania and elsewhere in eastern United States a steadily growing appreciation of the value of natural gas and more and more attempts to check its waste.

Development of Pennsylvania's Natural Gas Industry

In Pennsylvania, as elsewhere, the natural gas industry was an offshoot of the petroleum industry. In the early drilling for oil, begun by the famous Drake well, brought in in 1859, many of the wells also produced gas. Until about 1885, however, natural gas was considered a nuisance, and very few attempts were made to utilize it. The first great forward step in the natural gas industry came in 1883 when natural gas was piped to Pittsburgh for use in industries. In the same year the town of Washington, Pennsylvania, was supplied with gas from wells in the immediate neighborhood. For 25 years many of the steel mills, iron foundries, and glass factories relied solely upon natural gas for fuel. Then supplies began to fail, partly because of normal exhaustion and partly because adequate steps had not been taken to conserve and equalize production.

Importance of Pennsylvania's Industry Today

In 1931 Pennsylvania produced 74,797,000,000 cubic feet of natural gas with an estimated value at the wells of $21,092,754, just a little less than the value of petroleum produced in Pennsylvania in the same year. The State ranked sixth in the bulk of its natural gas production (second only to West Virginia among the states east of the Mississippi River) with about 4½ per cent of the United States total. In terms of estimated value at point of production, Pennsylvania was responsible for 18 per cent of the United States total and ranked third, being slightly outdistanced by West Virginia and by California. Explanation of this apparent discrepancy in bulk and value lies, of course, in the much better location of Pennsylvania and West Virginia producing areas with respect to markets than is true of most other important gas-producing states.

On December 31, 1930, Pennsylvania had approximately 20,000 producing gas wells, in this respect ranking first in the Union with West Virginia second. This seems, at first, a contradiction of the State's sixth place in gas production; but it must be remembered that the average gas well in the eastern states is small, making it imperative to have a large number of wells on which to

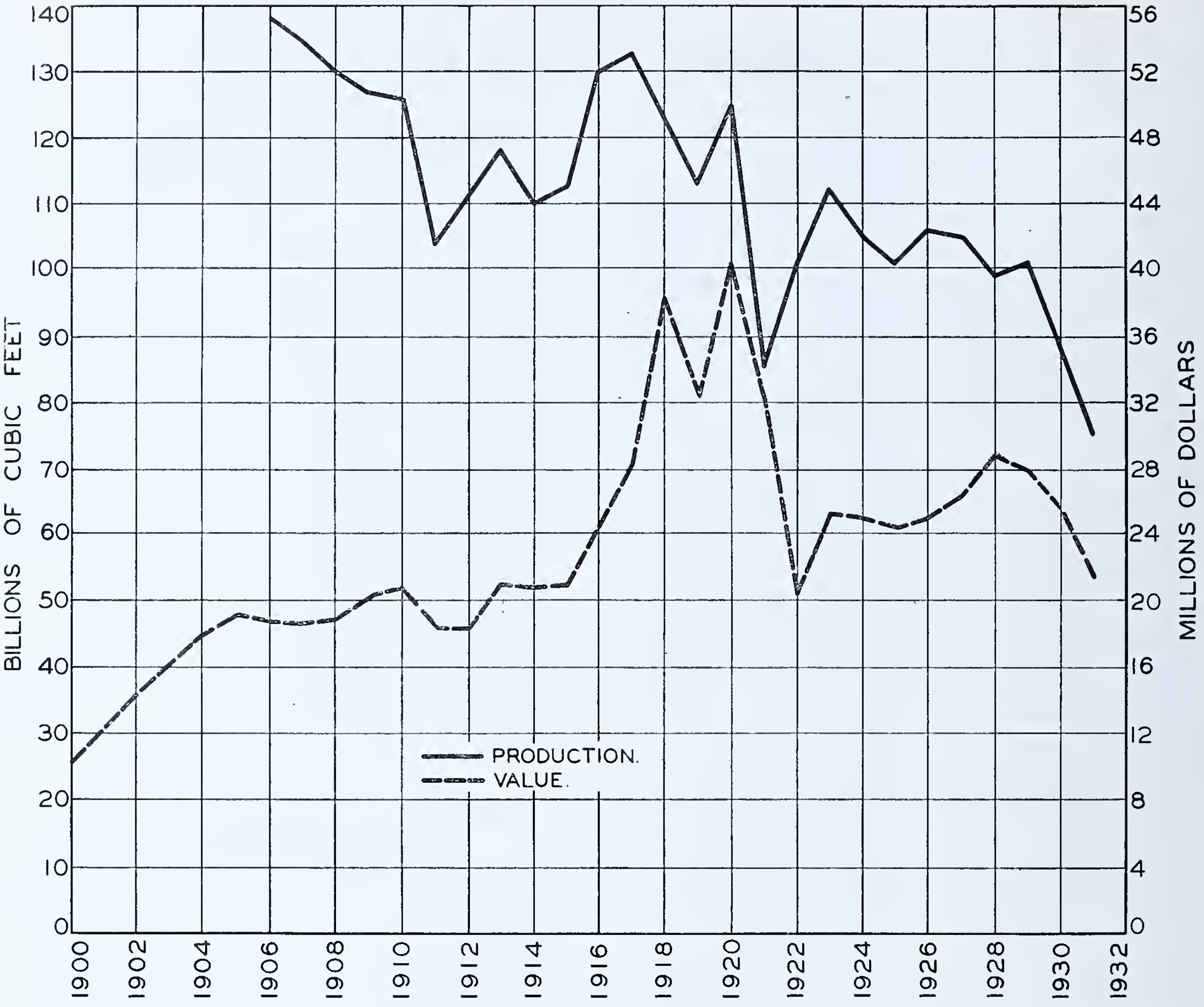

Fig. 48. Production and estimated total value at wells of natural gas produced in Pennsylvania during recent years. (Data from "Petroleum in the United States and Possessions" by Arnold and Kemnitzer.)

draw. While the states east of the Mississippi produced only 18 per cent of the total output of the United States in 1930, they possessed 81 per cent of the producing gas wells operating during that year.

According to the Pennsylvania Department of Internal Affairs the natural gas industry of Pennsylvania, including distribution, employed an average of 8,120 persons during 1930.

Location of the Industry In Pennsylvania

The oil and gas field map (Figure 41) shows that most of the oil and gas found in Pennsylvania occurs in a relatively narrow band crossing the western half of the State from northeast to southwest. Within this belt most of the gas fields are found in the eastern part, most of the oil occurrences in the west. Just as the percentage of volatile matter in coal increases from east to west in Pennsylvania, so, and for much the same reasons, the degree of volatilization of petroleum decreases. In the areas of low-volatile coal the same mountain-making compression which drove off the volatile matter from the coal left no oil and little or no gas for commercial development. Farther west, where more gas remains in the coal, compression was sufficient to change most of the oil in the oil sands to gas. Still farther west, where the coal is distinctly high-volatile, compression was not in general great enough to change the oil in the sand to gas; so oil wells are more common than gas wells, although these wells contain much gas dissolved in the oil.

Development has, of course, reflected occurrence of the gas (Figure 49). Except for a small flow in Erie County, production is restricted to the northeast-southwest belt visible in Figure 41. Within this belt two areas of particularly large

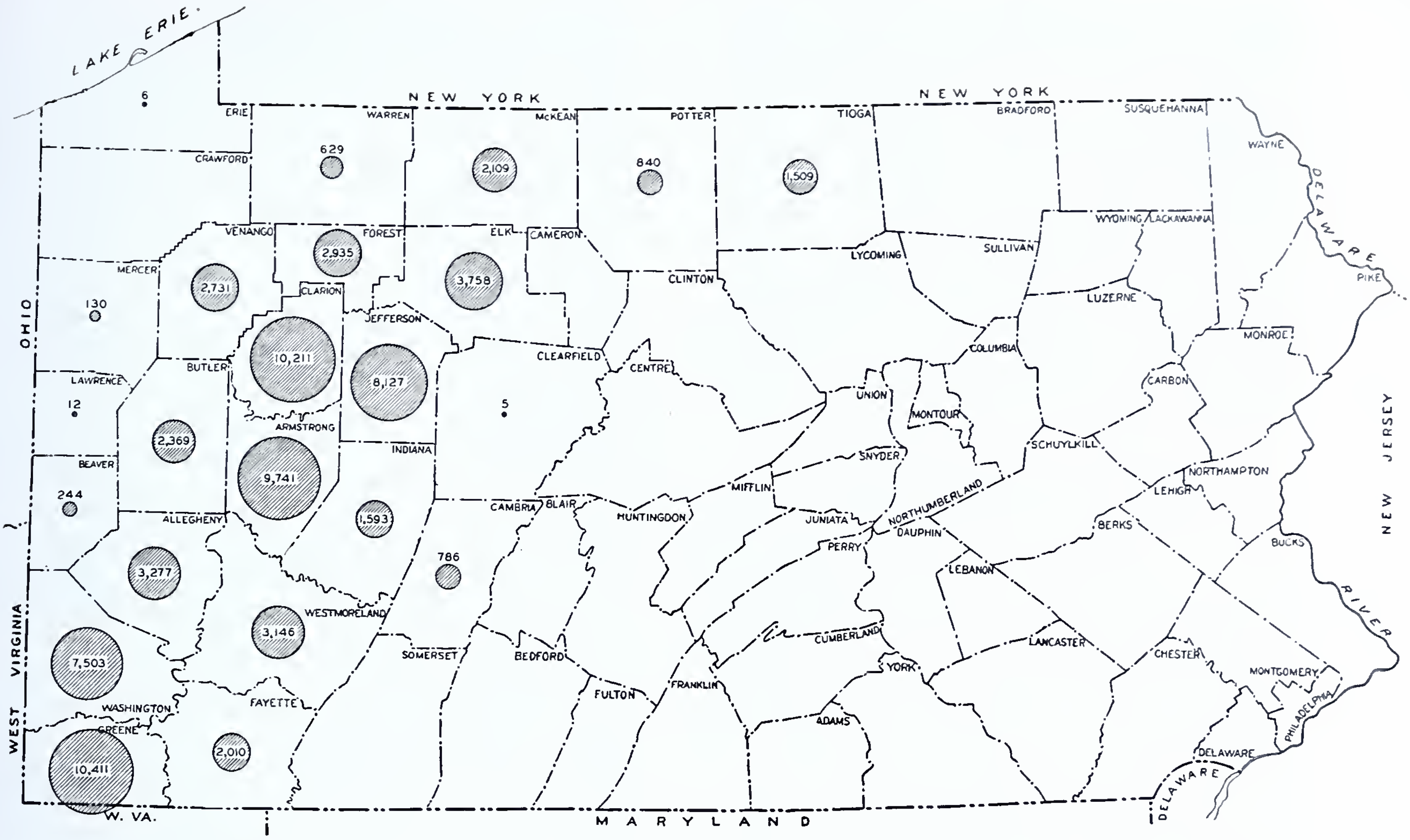

Fig. 49. Production of natural gas by counties, 1931. Numbers are millions of cubic feet. (Data from Pennsylvania Department of Internal Affairs.)

production stand out. One includes Armstrong, Clarion, and Jefferson counties; the other, Greene and Washington counties. A third region, the Tioga County Field, although not comparable to these two areas in point of present production is of special interest because of its newness and possible future importance.

The Tioga County Field

The actual producing area of the Tioga County Field lies in north central Tioga County and is known as the Farmington Field. It is not shown on the map of the oil and gas fields (Figure 41) since it had not been developed at the time the map was made. Opening of the Tioga County Field of Pennsylvania dates from September, 1930, when the first well was brought in. This discovery attracted operators to such an extent that by the first of January, 1931, practically all of the land in Tioga, Potter, Bradford, Susquehanna, Cameron, Clinton, and Lycoming counties was under lease.[1] By January 1, 1932[2], 100 locations had been tested or were being tested in Tioga County and its immediate vicinity. According to Robinson[3], writing during the first quarter of 1932, 25 producing wells had then been completed in Tioga County with a total aggregate open flow of 500,000,000 cubic feet of gas daily. Wells have varied from a few hundred thousand cubic feet of gas to nearly one hundred million cubic feet of gas per day, open flow, while rock pressure varies from 1650 to 1740 pounds. The average well depth is 4000 feet and the average size of a producing well is 20,000,000 cubic feet of gas per day.

In the development of a new field such as the one in Tioga County the question of markets naturally arises. Where will the gas move from this new field? One 14-inch pipe line has been completed to Williamsport, and a 20-inch line to Syracuse, New York. It is expected that the latter will transport 90,000,000 cubic feet of gas daily.

In 1931 Tioga County had already begun to rise as a natural gas producer. From 166,561,000 cubic feet in 1930 its production had increased to 1,509,468,000 cubic feet in 1931, in spite of a 17 per cent decline in the State's total during the same period. Now that the field has pipe line connections it seems probable that Tioga County will play a prominent role in the State's natural gas industry, and there is considerable interest in the possibility of New York City and New England obtaining gas from this field, the New Hebron Field in Potter County, and the adjacent producing area in the state of New York.[4] Early in 1932 rock pressure was said to be holding up satisfactorily in the Tioga County Field, but until more wells had been turned into the lines and the resulting effect on field pressure observed it was impossible to calculate the probable life and capacity of the field.

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[1] Robinson, J. French, Recent Gas Developments in Northern Pennsylvania and Southern New York, Proceedings of the Engineers' Society of Western Pennsylvania, Vol. 48, 1932, p. 81.

[2] Ashley, George H., and Cathcart, S. H., Gas in the Tioga Region, Pennsylvania, Bulletin No. 102A, Topographic and Geologic Survey, January, 1932, p. 2.

[3] Robinson, J. French, op. cit., p. 97.

Methods of Production

Gas wells are drilled by the same methods as oil wells. In fact, there are all gradations between oil wells and gas wells. Some wells produce petroleum with very little gas; some produce both petroleum and natural gas in important quantities, in such cases the gas usually being "wet" gas; and some, such as the wells in the new Tioga field, produce only gas and relatively "dry" gas at that. If gas is obtained, the well is closed in, valves regulating the amount of gas which will be allowed to flow into the natural gas lines.

Gas is a peculiar product in that it cannot be stored above ground to any appreciable extent. Therefore, a natural gas field is of very much greater importance if it occurs in an area of considerable demand. This is true to a greater degree than of any of the other natural fuels, and explains why Pennsylvania, although sixth in bulk of production in 1930, was third in value of production and very nearly equalled the leaders, West Virginia and California.

"There are now five major producing companies in the Appalachian district. These companies have been in existence for many years. They have grown through acquisition of territory, by merger, and by consolidation. One of these companies, the Carnegie Natural Gas Company, is a captive company which has been producing gas only to supply the United States Steel Corporation and allied companies. The principles of economies concerning that company are different from those of all other companies producing gas in this district.

"Fifteen years ago there was a distinct feeling of competition among gas companies. A cloak of secrecy was thrown about wells when they were drilled. Offset wells were numerous. Trading leases and wells were practically unheard of. This condition no longer exists. Officials of these companies meet regularly to trade information and to talk of problems which are common to all of them. These officials give papers before scientific societies and tell of their experiences and experiments. . . .

"Standardization of production has been brought about by blocking up leases, trading leases, trading wells, and the elimination of small-lot drilling. It has been common practice throughout the years for a group of men to lease a small block of acreage and raise enough funds to drill one or two wells. If one or both of these wells are dry the venture is a failure and the leases are abandoned before they are adequately tested and everybody loses money. This type of company has gradually fallen by the wayside. People have become wary of investments in small gas companies.

"The major companies of the Appalachian district have been making serious attempts to block up large areas of leases. The primary purpose is to hold them as reserve, but two other purposes are equally important. They are, first, to minimize the number and length of gathering lines, and second, to handle leases large enough to enable an operating company to develop its properties in the proper manner, unhampered by the fear of other companies draining the lands through offset wells. Leases are being traded with or without bonuses. Wells are being traded and sold by companies in order to reduce costs of production."[5]

Methods are considerably different in the Appalachian Field from those of the western fields. In the East, proximity to a ready market makes it possible to produce gas from small wells and sell it at a higher price than gas commands when produced farther from a market.

Preparation For Market

Most natural gas now produced is dried or stripped of its natural gasoline before it goes to the consumer.

The Natural Gasoline Industry

As natural gas comes from the ground it commonly contains some natural-gas gasoline, sometimes called "casing-head" gasoline, a highly volatile light oil contained as a vapor in the gas. The amount of this natural-gas gasoline or natural gasoline as it is commonly designated is very small where the gas is accompanied by little or no oil.

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[4] A gas line constructed for oil extends from Olean and Binghamton, New York, to Paterson, N. J. The Tioga County Field is connected with this line, which is, however, so small that it would be useless to extend it to New York City. A larger line will have to be built if the service is to be thus extended.

[5] Sisler, J. D., Economics of the Natural Gas Industry, Proceedings of the Engineers' Society of Western Pennsylvania, Vol. 47, 1931, pp. 110-111.

Where the gas is associated with oil, it becomes more or less saturated with the lightest fraction of the crude oil, the gasoline part of the crude. It is then known as "wet" gas in contrast to "dry" gas which contains very little natural gasoline.

For many years the natural gasoline present in natural gas was wasted, partly because there was no market for it among refiners and dispensers of motor fuel. The recovery of natural gasoline from natural gas was begun in Pennsylvania. In 1903 and 1904 experiments were carried on near Titusville, near Tideoute, and, later, at Mayburg, and Bradford. Experiments were established on a commercial basis in 1910, and the first commercial production was recorded in 1911. In that year Pennsylvania produced nearly 1,500,000 gallons, about 20 per cent of the United States total, and ranked third among the states; in 1930 Pennsylvania produced 16,713,000 gallons of natural gasoline, but this was a little less than 1 per cent of the United States total and the State ranked ninth. Pennsylvania's production in 1930 had a value at the plants of $1,229,000. To produce this natural gasoline 41,848,000,000 cubic feet of natural gas were treated in Pennsylvania, or about one-half of the total natural gas produced. Some of the natural gases of Pennsylvania are exceptionally rich in gasoline, but the average yield for the entire State is low. Though some of the gas yields from 6-10 gallons per thousand cubic feet, the average yield was only .4 gallon per thousand cubic feet treated in 1930.

The career of the natural-gas gasoline industry in Pennsylvania may be seen from its curves of production and value (Figure 50). Though beginning in Pennsylvania the recovery of natural gasoline from natural gas has spread to every important gas and oil field in the country.

Removal of natural gasoline does not make the remaining gas artificial or manufactured, the process of gasoline removal being merely a separation of two crude natural products. The separation of natural gasoline leaves a natural gas of normal heating value. It is, in fact, a more usable product than before separation, since natural gasoline, if left in the gas, has an injurious effect on public utility lines.

Gasoline recovered from natural gas is sometimes referred to as "wild" because it is more volatile than the ordinary refinery gasoline. It is too volatile a product to use in its natural state in motor cars, and is, therefore, blended or mixed with less volatile fractions to produce a blended motor fuel. Increasing demands for gasoline have resulted in a tendency to distill more and more of the heavier hydrocarbons into the gasoline fraction, until a product is obtained which will not

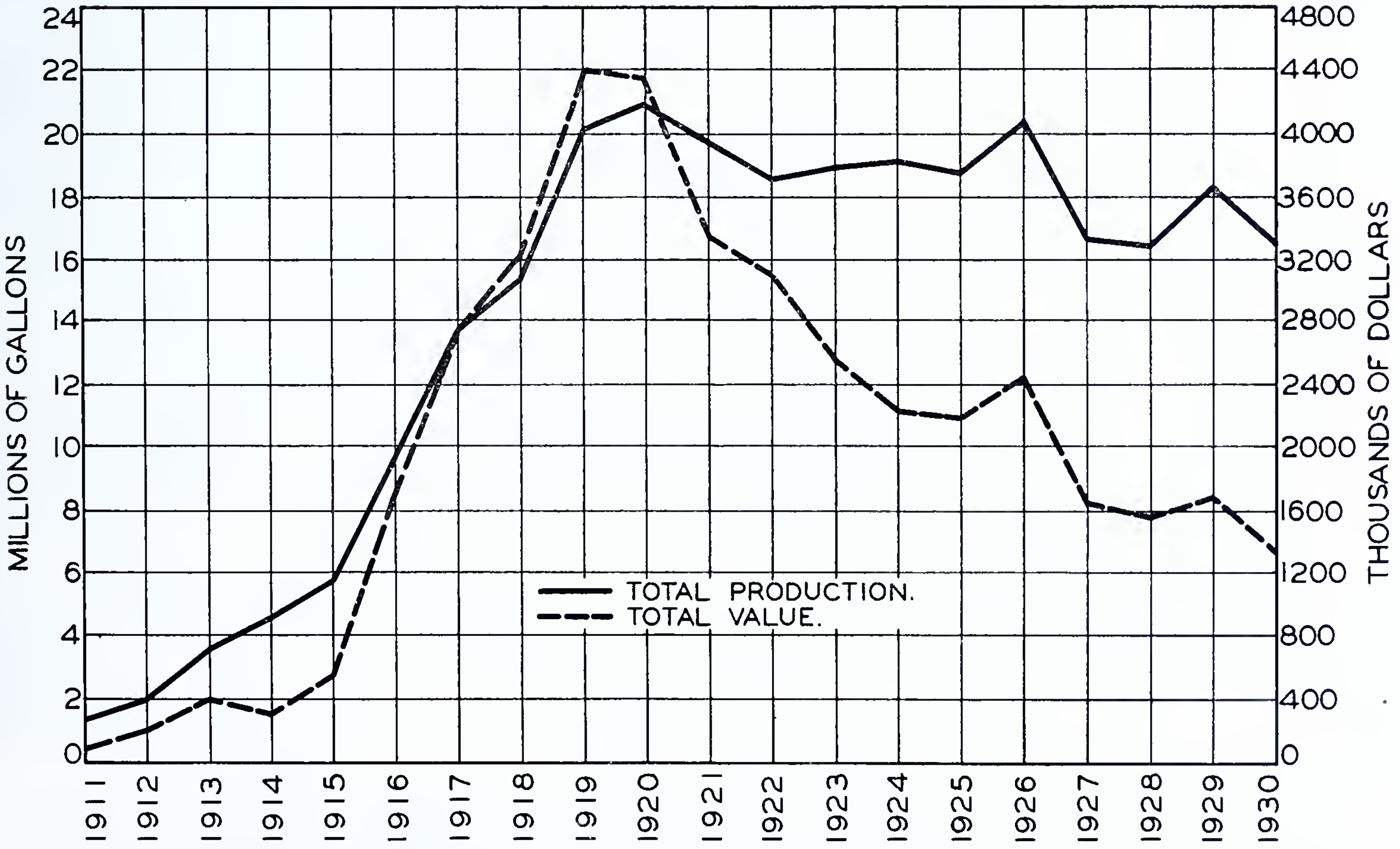

Fig. 50. Production and total value of natural-gas gasoline produced in Pennsylvania since 1911. (Data from "Petroleum in the United States and Possessions" by Arnold and Kemnitzer.)

pass specifications for motor gasoline. These gasolines are blended with the highly volatile natural gasoline in order to supply them with the proper proportion of low-boiling constituents. Thus, natural gasoline plays an important part in the motor fuel supply. Moreover, the utilization of the gasoline from natural gas for making gasoline constitutes one of the most important achievements of the industry toward conservation, since this product was formerly permitted to escape into the air.

The natural gasoline plants of Pennsylvania are, as might be expected, all located in the oil and gas belt of western Pennsylvania (Figure 51). Moreover, they seem to be concentrated in the western part of this belt where oil and gas occur together and where the gas is, therefore, "wet". Greene County, though it had only seven operating natural gasoline plants, led in gallons of natural gasoline produced in 1930. Venango County with about one-half as large a production was second, and Warren County third.

Compression

As part of the preparation of natural gas for delivery it must be compressed, and a compressor is part of the delivery equipment of a natural gas system. This gives the gas the necessary driving force to make it flow through the line. Pressure regulators reduce this pressure again near the point of consumption.

The Uses of Natural Gas

The uses of natural gas are many and they show distinct regional variation.

In Oklahoma and Texas a large amount of gas is used for drilling, pumping, operating gasoline plants, repressuring oil sands, and kindred uses. In Texas and Louisiana carbon black manufacture is of considerable relative importance. Neither of these uses is important in Pennsylvania. No carbon black is manufactured, and field use accounted for only about 6 per cent of the State's total use of natural gas in 1930, while about 40 per cent of all the natural gas used in the United States was for field use and about 14 per cent for carbon black manufacture. It is not surprising that neither of these uses is important in Pennsylvania, since they are relatively low-grade uses depending upon cheap gas and thriving in gas producing areas some distance from market.

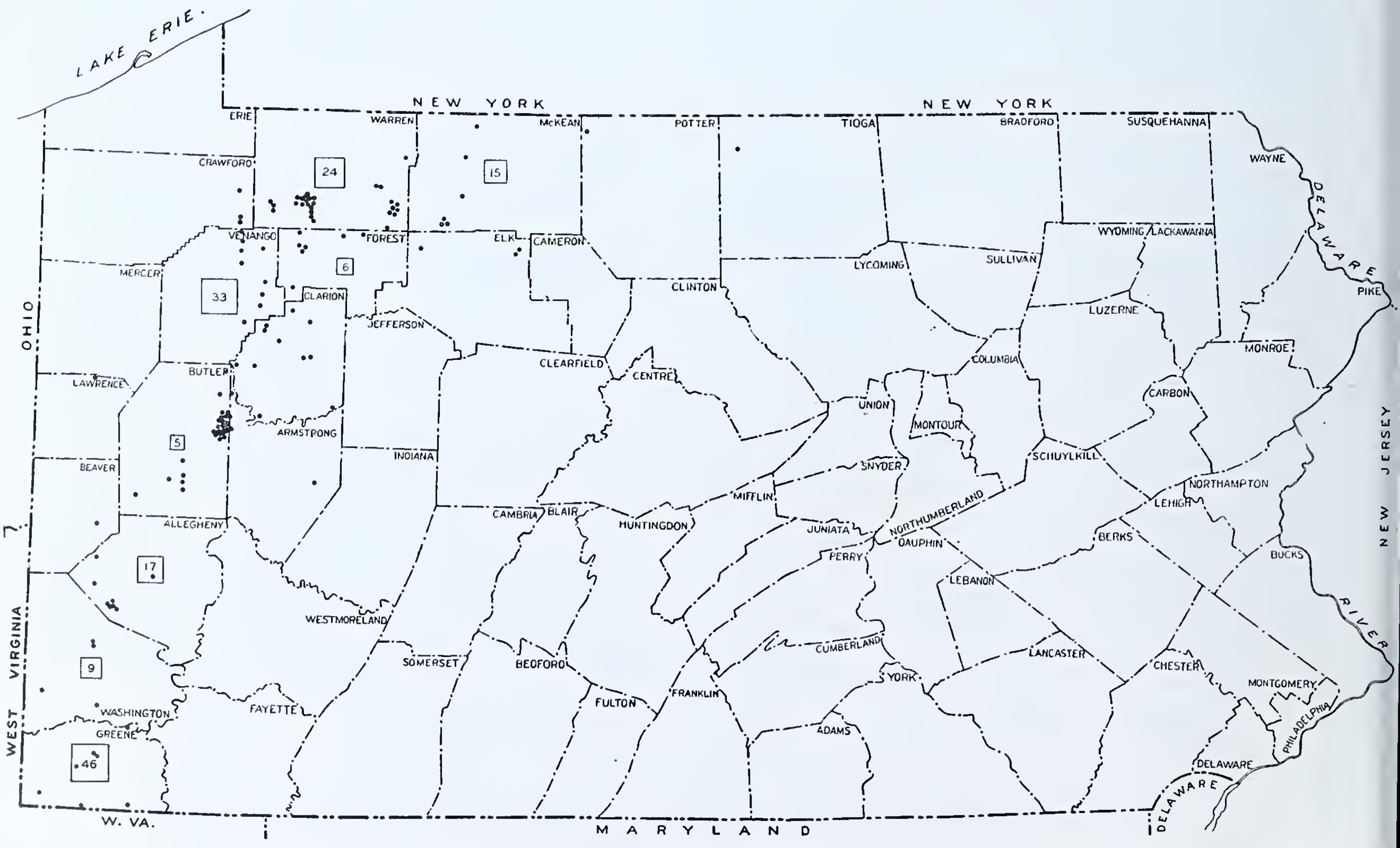

Fig. 51. Natural gasoline manufacture in Pennsylvania. Each dot represents one natural gasoline plant in existence on January 1, 1930. Squares represent production of natural gasoline in 1930 for all counties producing 500,000 gallons or more. Numbers in squares are 1930 production figures in hundreds of thousands of gallons. (Data from United States Bureau of Mines.)

On the other hand, nearness to a consuming population resulted in nearly 50 per cent of Pennsylvania's natural gas consumption being used for domestic and commercial purposes (Figure 52) in contrast to about 20 per cent for the United States as a whole. "Other industrial uses"—steel plants, glass works, ice plants, brick and terra cotta establishments, and many other industries where absolute control of temperature is necessary—accounted for almost as much gas in Pennsylvania as domestic and commercial use. Miscellaneous field use, as has been pointed out, consumed about 6 per cent of the total natural gas used in Pennsylvania; and less than 1 per cent of the total natural gas used was for fuel at petroleum refineries. Though natural gas is used in cement manufacturing in some states, there is none so used in Pennsylvania. It has not been available in the eastern part of the State, the main stronghold of the cement industry, while in western Pennsylvania high-volatile bituminous coal is readily accessible.

Domestic use is generally taken to mean cooking, heating, and lighting, although house cooling and refrigeration are being added to these "domestic" uses. Commercial use, which took about one-seventh as much of the natural gas used in Pennsylvania in 1930 as domestic use, consists of use in stores and shops.

Distribution of Natural Gas

Natural gas reaches the consumers through pipe lines, which are being increased by thousands of miles each year in the United States. In some states a considerable amount of gas is used close to the source of supply by carbon black producers, refining companies, etc. and for such uses pipeline costs and transmission problems are not of great importance. There is, however, no carbon black manufacture in Pennsylvania, and the other uses at the place of production are unimportant, all but about 6 per cent of the natural gas consumed being piped some distance to its consumers.

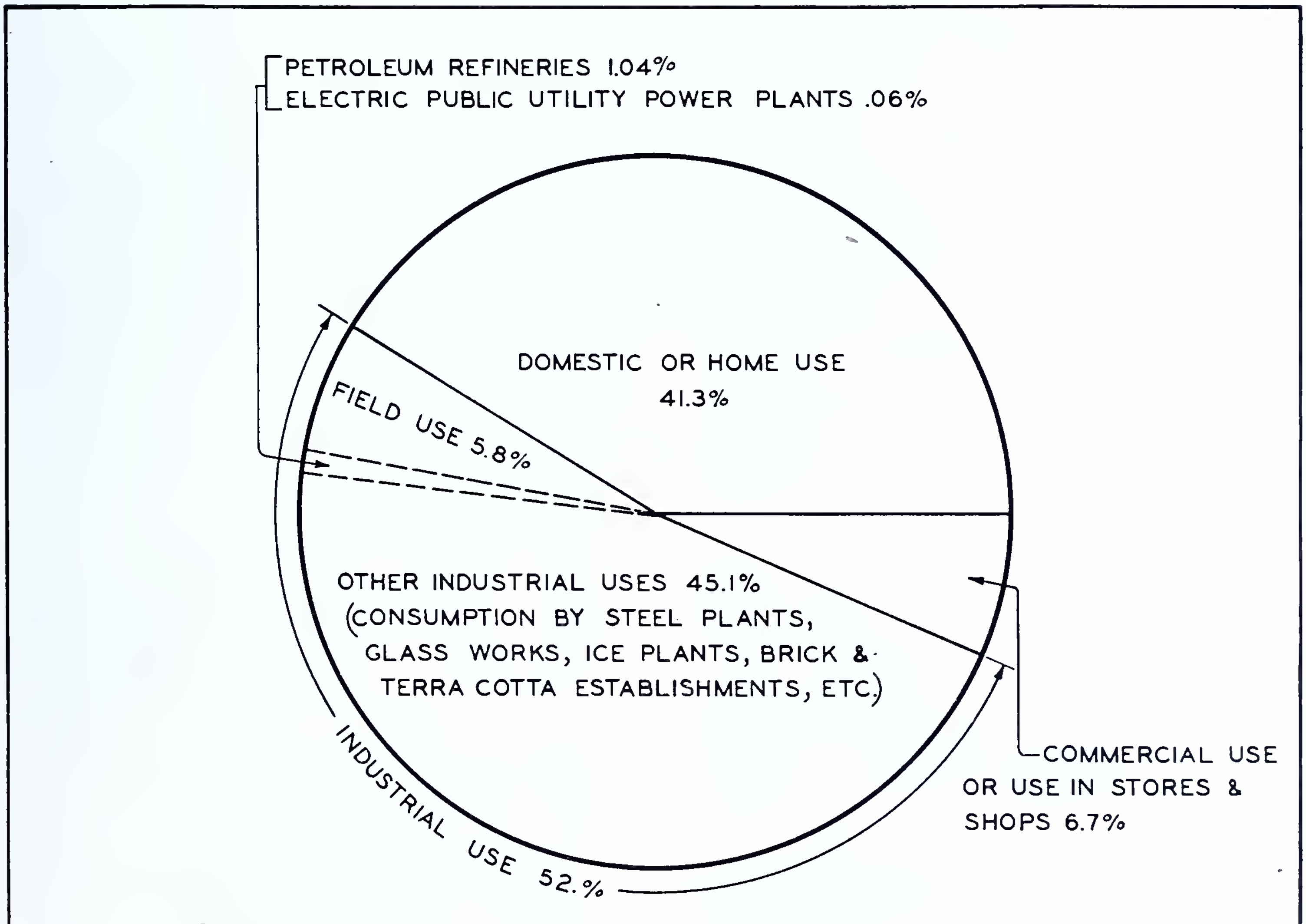

Fig. 52. Uses made of Pennsylvania natural gas in 1930. (Data from Mineral Resources of the United States.)

It is said that prior to 1927 transportation of natural gas for a distance of 250 miles or more was regarded as an outstanding engineering accomplishment, and, of course, most of the natural gas distributed in Pennsylvania was piped much shorter distances. Nevertheless, for over 90 per cent of the natural gas consumed pipe-line costs and transmission problems must be considered.

Recent developments in long-distance transportation of natural gas have greatly extended its range of distribution. Every natural gas distribution project requires consideration of: (1) the supply of natural gas available for long-time periods, (2) availability of markets, and (3) costs of construction and operation. The first two items were of greatest weight in the development of long-distance transmission. An assured gas reserve, capable of supplying a market over a long-time period, and established high-grade markets to absorb the production—these were necessary before capital could be interested. With these conditions adequately established, so that amortization of investment in connecting pipe lines was assured long before the depletion of available reserves, the building of long-distance pipe lines and improvement in the technology of transmission followed as matters of course, merely serving to carry forward the movement already initiated.

The use of large-diameter pipe made of high-carbon steel with greater ultimate strength than that of pipe previously used and the handling of gas at high pressures have been developments of outstanding importance. The resultant lowering of costs has been important, but such technical developments in gas transmission were sure to result from a growing recognition of the value of natural gas and the spur of a surplus in areas of production with a large potential demand in regions too far away to be served by the short pipe lines of yesterday.

The principal item of cost in a pipe-line project is the pipe itself. Consideration is now being given to the economies that may be effected through use of lines of smaller diameter and greater wall thickness that will transmit gas under pressures as high as 1500 pounds per square inch. Such pipe will cost more per lineal foot, but the cost per cubic foot of delivered natural gas is said to be less.

Another development by which some companies have reduced costs is by the use of ''telescope lines''. This may be accomplished by using sections of pipe of different diameters, the diameter increasing in the direction of flow, as pressure decreases; or a line of uniform diameter may be used with the weight of pipe decreasing in the direction of flow so that pipe with thinner walls is used where the pressures are lower. By the use of telescope lines the total weight of pipe used is reduced and hence the cost. Such lines are said to be especially economical where initial pressure is high and where there are long distances between compressor stations.

Better welding methods, protective coatings, greater lengths of pipe, improvements in pipeline construction methods by use of machinery and well-trained crews, and multiple compressor stations are other developments by which economies have been effected.

Long-Distance Pipe Lines In Relation to Pennsylvania and its Natural Gas Industry

The continued and rapid extension of long-distance pipe lines has been a dominant feature of the natural gas industry of the United States within the last four or five years. Lines which have been completed from Texas to Chicago and to Indianapolis occupy the center of the stage, but other long lines are built or being built which affect Pennsylvania more directly.

Old oil lines now used for gas extend from Pittsburgh to Olean, New York, and from there to Paterson, New Jersey. This line is too small in diameter to be of much importance, and it can never supply important amounts of gas to New York City or New England. Old oil lines across southern Pennsylvania carry natural gas to Philadelphia and vicinity, and are being connected with a line still farther south, by means of which Washington, D. C., is already receiving natural gas from West Virgina.

The natural gas producing industry of Pennsylvania is not likely to take much part in long-distance transmission of gas. The total production of western Pennsylvania is not great, and it may be expected to decline, so the natural gas producers of that section will not be seeking to extend their markets. It is the large, new, flush fields of Texas and Oklahoma, far from large consuming areas, that may be expected to make most use of long-distance transmission. There will be a tendency, however, for new eastern fields, such as the Tioga County Field, to make use of longer pipe lines, marketing their gas at more distant points than is customary throughout most of western Pennsylvania. Tioga gas may thus ultimately move to the Atlantic Seaboard for its markets.

It has been suggested[6] that the natural gas industry of the Appalachian region may be affected by the transportation of natural gas from the Mid-Continent Field in another way. Only a few hundred miles more of pipe line must be laid to deliver Texas gas (which is already at Indianapolis) to Pittsburgh. A glance into the future would suggest that it will not be many years before Mid-Continent gas is on the market in seaboard consuming centers in competition with Appalachian gas.

Pennsylvania will be affected in still a third way by long-distance natural gas transmission. Natural gas is already available in eastern Pennsylvania and farther south in coastal cities, chiefly for mixing with city gas. This natural gas competes with other fuels in an already crowded market, and this competition may become increasingly serious as larger supplies of natural gas become available.

Other Distribution Problems

An important problem of distribution is keeping the capacity of lines as small as possible in order to lower costs. Operating against this is the great winter demand for gas, requiring large capacity. The problem can in some cases be partly solved by the use of depleted oil sands for natural gas storage. Where such sands occur near points of consumption the natural gas (after having been piped from the point of production) can be stored in them when demand is small, and is available for delivery during periods of strong demand. Under these conditions large-diameter pipe is necessary only from the storage sand to the point of consumption. This greatly reduces pipe-line costs and hence the cost of distribution. The same storage, applied to manufactured gas, permits saving through smaller initial investment in plant capacity than would otherwise be necessary. In either case, storage in old oil sands is said often to enrich the gas.

The cost of natural gas delivered to consumers is increased a great deal by transportation, as pipe lines are costly to build and maintain. Hence, there is a great difference between the value of gas at remote points of production and its value when delivered to the consumer in a populous region. This factor gives gas at the well a much higher value in Pennsylvania than in Texas or Oklahoma.

Most natural gas does not move far, but this movement may be across a state line and the new developments in the building of long pipe lines are yearly increasing such interstate movements. In 1931 Pennsylvania sent 9,126,000,000 cubic feet of gas to New York, 2,131,000,000 cubic feet to Ohio, 262,000,000 cubic feet to West Virginia and 36,000,000 cubic feet to Canada. During the same year Pennsylvania received 29,387,000,000 cubic feet of natural gas from West Virginia.

Marketing of Natural Gas

Areas of dense population and industrial development are the greatest natural gas markets. Though the large amount of natural gas used for field purposes causes the states west of the Mississippi to exceed those east of it in natural gas use, the northeastern quarter of the United States is the highest-grade market with the greatest potentialities. With modern long-distance piping this northeastern market is being reached from ever increasing distances.

In Pennsylvania, production has been confined to the oil and gas belt of the western part of the State, and, until the present long-distance piping, consumption, too, was confined to approximately the western half of the State. Though household use is outstanding, the iron and steel industry, the glass industry, and others have furnished important markets for the natural gas produced in western Pennsylvania.

Long-distance piping would seem at first glance to extend the market for natural gas clear to the Atlantic Seaboard. As a matter of fact, however, it has already been pointed out that most of the western Pennsylvania gas will probably continue to be used in the general vicinity of its production. The picture is more likely to be one of Mid-Continent gas and gas from West Virginia competing with anthracite, bituminous coal, etc. on the Atlantic Seaboard.

The rise in popularity of gas has been discussed in earlier chapters, and will not be gone into here. Suffice it to say that in domestic and commercial uses as well as in industry natural gas is competing more and more successfully with bituminous coal, anthracite, and other solid fuels (Figure 21). Indeed during the last few years the country's total natural gas consumption has been increasing steadily (Figure 53), while the consumption of bituminous coal and anthracite has either remained about stationary or declined.

Standardization of markets has been a subject of much interest to companies selling gas in the

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[6] Sisler, J. D., op. cit., p. 110.

Appalachian region. Although domestic gas usually sells at a higher price than industrial gas, the profit is less because of the slack summer period. The ideal situation is attained when domestic and industrial sales are so combined as to keep an almost constant load every month of the year. The sale of gas for summer cooling of homes and other buildings is a step in this same direction. It has been pointed out, also, that by underground storage the load can be evened and the situation bettered.

The natural gas industry is classed as a public utility because many states, through a regulatory board or commission, set the sale price of natural gas to consumers. This regulation has its good features. The sale price is more or less constant, and operators know that costs of production, of sales, and of distribution must be within certain limits to make a profit. They are not at sea like the operators in the bituminous coal industry.

Changes in Pennsylvania's Importance as a Natural Gas Producer

There has been a steady though gradual decline in Pennsylvania's importance as a natural gas producer for a number of years (Figure 54). Thus, though the State produced 25 per cent of the Nation's total bulk of natural gas in 1910, it produced only about 4.5 per cent of this total in 1931. During the same period Pennsylvania's proportion of the total value (at wells) of gas produced declined much less markedly. More and more, natural gas production has been shifting to sections of the country where population density is low and the market for gas limited. In such localities gas commands relatively low prices. It is not surprising, therefore, that Pennsylvania with its excellent market location has been much better able to maintain its proportion of the nation's total value of gas produced than its proportion of the total bulk.

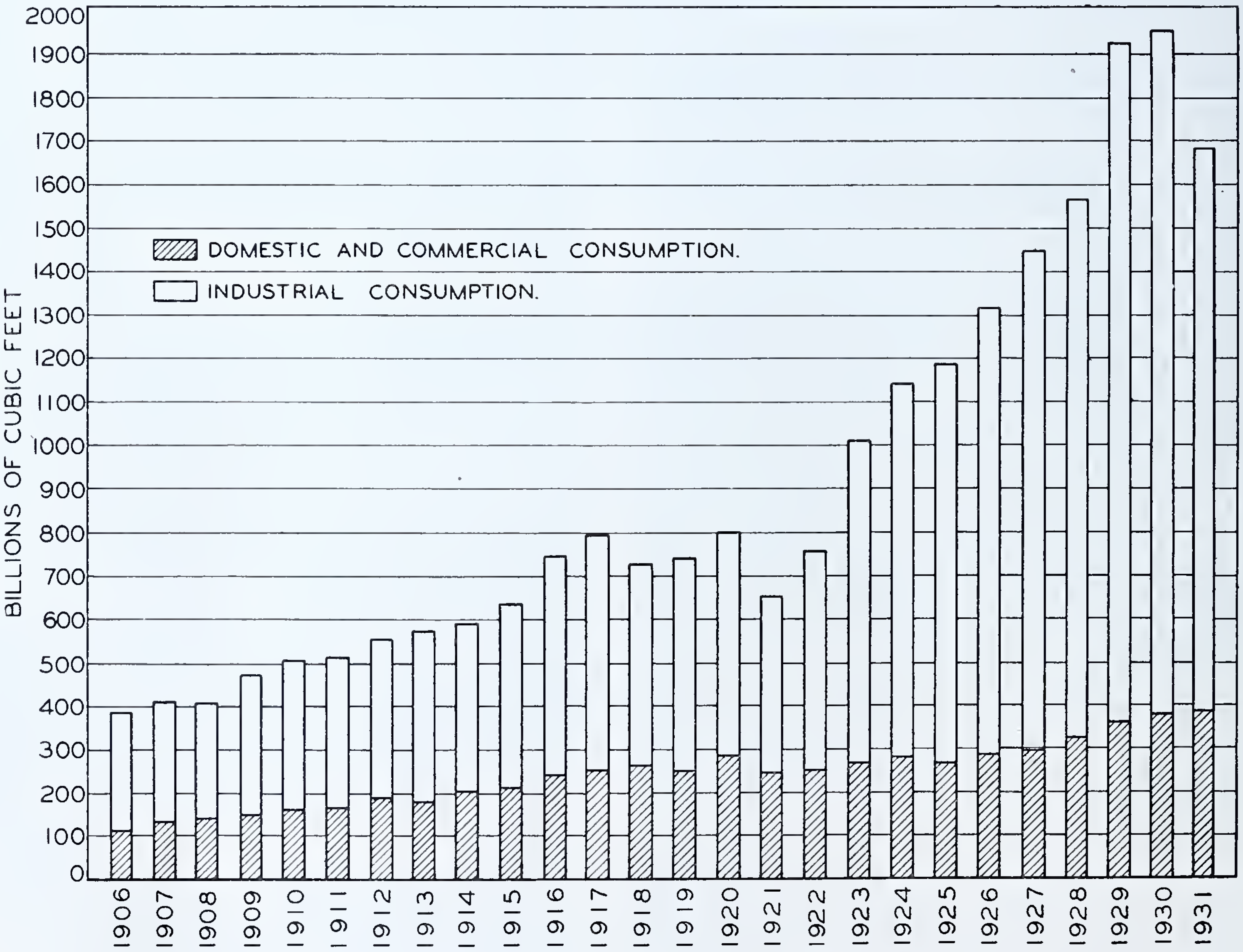

Fig. 53. Consumption of natural gas in the United States, 1906 to 1930. (Data from Mineral Resources of the United States.)

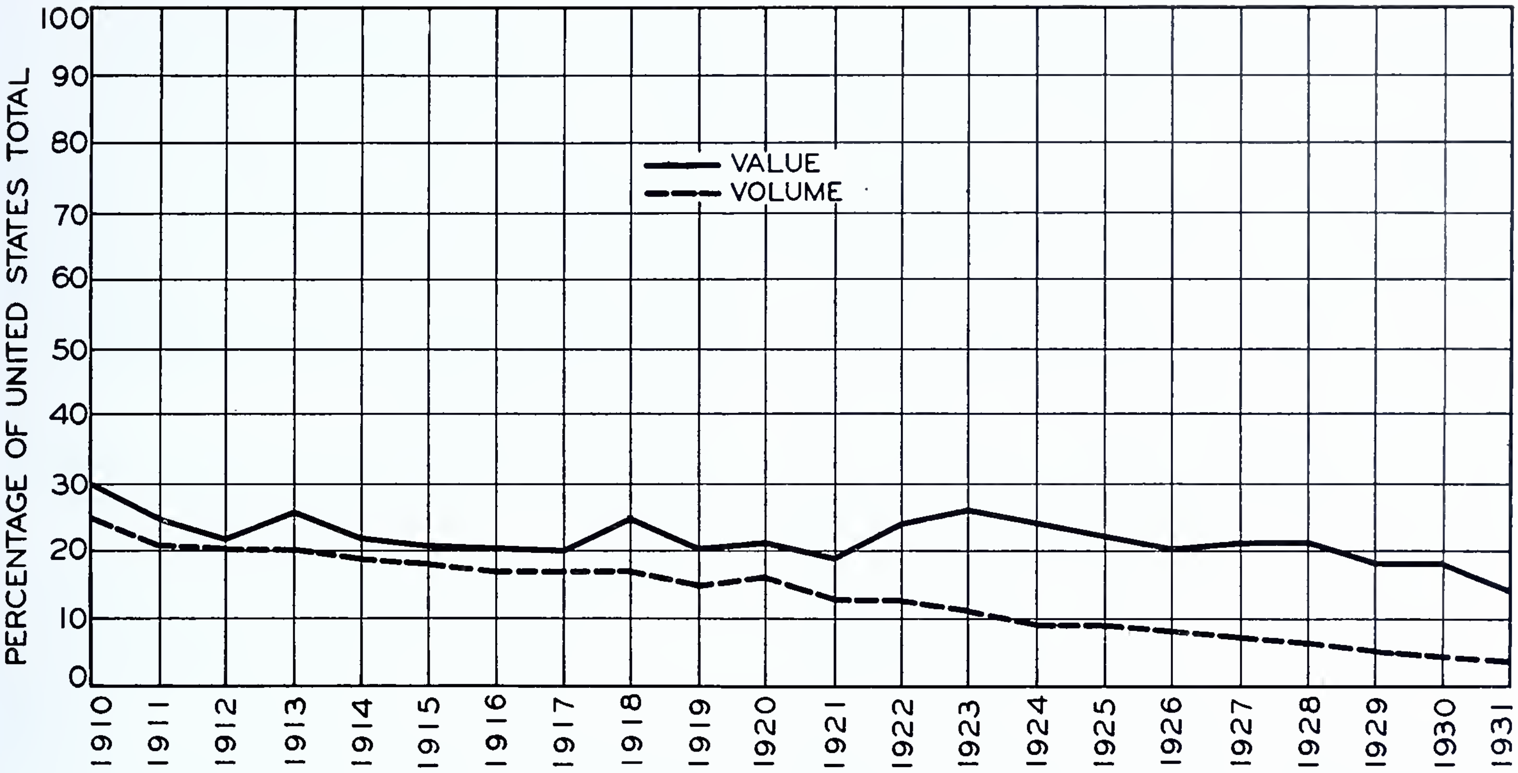

Fig. 54. Recent trends in the relative importance of Pennsylvania as a producer of natural gas. (Data from Mineral Resources of the United States.)

The Waste of Natural Gas

There is no other fuel which has been as extensively wasted as natural gas. The Federal Oil Conservation Board characterized the waste of natural gas as a triple waste—the waste of a gaseous fuel, the loss of gasoline contained in the natural gas, and the loss occasioned by the dissipation of gas pressure in oil wells with which the gas is associated. These facts are beginning to be realized, and gas waste is being very much reduced, particularly in states such as Pennsylvania where accessible markets give natural gas and the other wasted products a higher value than in more remote producing fields.

Proper spacing of wells is an important factor in the conservation of gas. When gas is found in areas of small separate leases, dozens of wells are drilled where a few would be sufficient, in a few months the reservoirs are drained, and even a good gas pool may be found not to have paid for connecting it with markets. Elimination of little operations by consolidation or purchase conserves the supply of natural gas and removes factors which are definitely against stabilization of the natural gas industry.

A serious waste of money if not gas has been incurred by town-lot drilling several times in the history of Pennsylvania gas production. Gas marketing requires a considerable investment in pipe lines, compressors, etc. so it is highly uneconomical for a number of different companies to drill many holes and quickly drain the territory.

It has been pointed out that natural gas cannot be stored above ground to any appreciable extent, nor is it generally transported for great distances. If a region depends upon natural gas for domestic fuel or has built up industries based upon its use, conservation is particularly important. Though the total gas production in the United States is increasing steadily, most natural gas areas in the East are suffering declines. Thus far, piping gas to a community from any considerable distance has been found to be uneconomical. Hence, it has been particularly important that local reserves be conserved and protected. True, manufactured gas can be substituted for natural gas in such a community, but this usually means an increase in cost and a lowering of heat value per cubic foot which may seriously affect industries built upon the use of natural gas.

Major Problems of the Industry

One problem which concerns the natural gas industry today arises in connection with long-distance gas transmission. How much natural gas can gas companies along the Atlantic Seaboard purchase? How far will the delivered price of natural gas allow them to go in readjusting their distribution systems, readjustment of rate structures, readjustment of consumers' appliances, increase in general expense, etc.? There is apparently an economic limit beyond which the pipeline company cannot lower cost and yet properly safeguard the supply and earn a fair return on its investment. This problem remains to be solved.

Long-distance transmission lines do not provide flexibility in supplying the consuming centers, so the problem of storage at points of immediate consumption becomes a large one. Surface storage is very expensive. In the Appalachian district the problem has been partly solved by underground storage in depleted sands, and this seems to be feasible in most depleted oil or gas sands. Indeed, it may ultimately prove possible to inject specified quantities of manufactured and natural gas into an underground reservoir at one place and draw it out at another thoroughly mixed and ready to deliver to the consumer during the winter months or at other times of peak demand. The general opinion is that underground storage of gas will not work in sands which have never contained oil or gas. Storage in abandoned mines, another plan which has been suggested, is hardly practicable because of the difficulty of sealing the mine tightly enough.

Rate structures are now under fire and are a constant problem of the natural gas industry.

Cracked natural gas may become important in the future. The cracking process, which produces from natural gas a lower heat value gas of greater bulk, may double the reserve by volume of natural gas if it is generally applied.

It has been pointed out that with minor interruptions the daily production of natural gas from the wells in Pennsylvania and West Virginia will decrease from year to year. One result of this production decline already is that more attention is being given to both new and old wells. Systematic cleaning, replacing, and repairing of casing and tubing are among the intensive measures which are being undertaken. Wells which produced less than 50,000 cubic feet per day were formerly abandoned; now wells producing 5,000 cubic feet are capped and saved for future production.

Deep drilling should increase from year to year as the supply of natural gas decreases and the market price rises.

An almost super-gas system has been visualized to connect western United States with the East and the North with the South, an extension of gas use which amounts to a great invasion of the coal markets. It has been suggested that the proper move for the coal operators is to install gas plants, thus going along with the trend. Sooner or later coal products will be needed to meet the growing demand for gas fuel. The coal operator of the future may very well be manufacturing gas and storing it in depleted sands beneath his mine.

It becomes increasingly evident that the several fuels are not to constitute such distinct industries in the future as they have in the past. The coal industry produces gas and may also produce petroleum, the natural gas industry in its distribution phase merges with the manufactured gas industry based on coal, manufactured gas may be stored underground and even mixed with natural gas underground.

A use of natural gas not discussed is for repressuring oil sands from which the gas has been exhausted in order to promote maximum recovery of oil.

The most serious problem of the natural gas industry of Pennsylvania is the prevention of waste to the end that the industry be prolonged and that the maximum ultimate recovery of gas be attained. It, like the other fuels, is faced with the problem of finding its proper place in the competitive struggle between the fuels. Since the State's production of natural gas is declining, and since the superiority of natural gas over manufactured gas is generally recognized, it is in a much better condition than most of the other fuels. As natural gas becomes more scarce it is probable that less will be used directly and more will be mixed with manufactured gas to enrich the latter.

Future of Natural Gas Industry of Pennsylvania

How long will our natural gas supply last? How long will Pennsylvania continue to have an important natural gas industry?

In 1921 the following opinion was expressed:

"If no more wells were drilled, it might be closely estimated that the production of natural gas in Pennsylvania will decline rapidly at first then more and more slowly to extinction in 30 or 40 years. In 1918 the gas production of the State was nearly 124,000,000,000 cubic feet. If not replenished by new drilling it is probable that 5 years would see that amount reduced one-half, ten years to one-quarter and so on, yielding a total future production of less than 1,000,000,000 000 cubic feet".[7]

New drilling has of course been going on since the preceding statement was made and part of the drilling has been successful. When the possibility of new developments is taken into consideration it is difficult, indeed, to make any predictions regarding the future of the industry. Certainly it is true that Pennsylvania's annual production has been declining, and no marked reversal in this trend seems probable. The shallow-sand pools have been, very largely, developed, their production having been depleted to the point that, in many cases, a partial vacuum method must now be used to obtain the gas. The new factor in Pennsylvania's natural gas production is deeper drilling, the testing, that is, of deeper sands. Already such drilling has developed two important gas areas in the Oriskany Sand in Tioga and Potter counties, and undoubtedly other new pools will be discovered in the deeper sands. The situation in brief is that drilling of the shallow sands is largely completed, and exploration and drilling of the deeper sands is going on. When this deeper phase of exploration and development is completed, Pennsylvania's future as a natural gas producing state will be a matter of but a few years.

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[7] Ashley, George H., and Robinson, J. French, The Oil and Gas Fields of Pennsylvania, Volume 1, Pennsylvania Geological Survey, 1922, p. 38.

VIII

THE COMMON ROCK INDUSTRIES OF PENNSYLVANIA

Introduction

It is customary when discussing Pennsylvania's mineral industries to mention coal first, because Pennsylvania is so pre-eminently a coal-producing State and because coal bulks so large in the State's industrial life. Indeed, so accustomed are people to thinking of Pennsylvania as a coal producer that they frequently overlook or quite ignore many other important mineral industries. The State has a second gigantic extractive industry in the mining and quarrying of common rocks —an industry which produces each year a tonnage more than one-third as large as the tonnage of bituminous coal and more than two-thirds as large as that of anthracite. In addition to the size of the common rock industry, the analogy to coal is further carried out in that the pits and quarries from which forty or fifty million tons of rock are taken each year are scattered over a considerable area; and, still more like coal, the common rocks enter into many different industries forming, as they do, the back bone of all construction work.

Pennsylvania is not unique in the fact that common rocks play such an important role in its welfare. Rock and rock products are everywhere finding greater and more varied uses each year. Partly owing to the fact that wood has become scarce and man-made structures such as dams, houses, sky scrapers, bridges, and highways have greatly increased in both size and number, the lowly common rocks of the earth's crust are more and more proving their worth. Indeed, some people believe that we are living in a "New Stone Age" which is rapidly replacing or at least sharing the stage with the well-recognized "Steel Age". This is particularly true in the United States where an annual output of nearly 400,000,000 tons of common rocks places this industry or group of industries second only to coal mining among the extractive mineral industries. It is further significant that in a country which produces and uses such vast quantities of rock, Pennsylvania is the leading producer (in terms of tonnage) among the States.

In spite of the importance of the common rocks in our present civilization their value per ton is quite low, averaging about $1.34 for Pennsylvania in 1929 according to calculations by the writer. Moreover, the total value of such common rocks produced in Pennsylvania is only about one-fourth as great as the value of bituminous coal and only one-sixth as great as that of anthracite. It is to be expected that when a commodity is bulky in proportion to its worth, and is widespread in its distribution, it will not find markets very far afield. Transportation costs quickly increase the sales price, until a similar product produced nearer the market can successfully compete with it. Different rock materials can be used interchangeably for many purposes, and one rock material may replace another on the market merely because it is cheaper. Price is the most important consideration in most cases.

Rocks suitable for most industrial and structural uses are so widespread and so abundant that most countries in the world are self-sufficing, causing international trade in such commodities to be quite insignificant. Such trade is largely confined to small quantities of material which may be used for special purposes, e. g., special kinds of marble from southern Europe, or to local movement for short distances where especially cheap transportation facilities permit.

Common rock materials produced in Pennsylvania in 1929 are estimated to have totalled about 50,000,000 short tons, and to have had a value of nearly $65,000,000 (Figure 55). Limestone made up about half of each of these totals, while sand and gravel and clay were next in order. A number of other rocks or rock materials contributed to the totals in somewhat smaller amounts.

The common rocks of Pennsylvania have an almost infinite variety of uses, but the great bulk of the material is used for a few major purposes (Figures 56 and 57). Outstanding among these is the use of rock materials for concrete, plaster, and road metal. Data are not available for separating building and paving except in the case of sand and gravel. Cement manufacturing ranks second both in tonnage and value of rock materials consumed, while the iron and steel industry (because of its demand for fluxing stone) and the clay-products industries are other large consumers. The lime-manufacturing industry, the building trade, the glass-manufacturing industry, the railroads (through demands for ballast), and

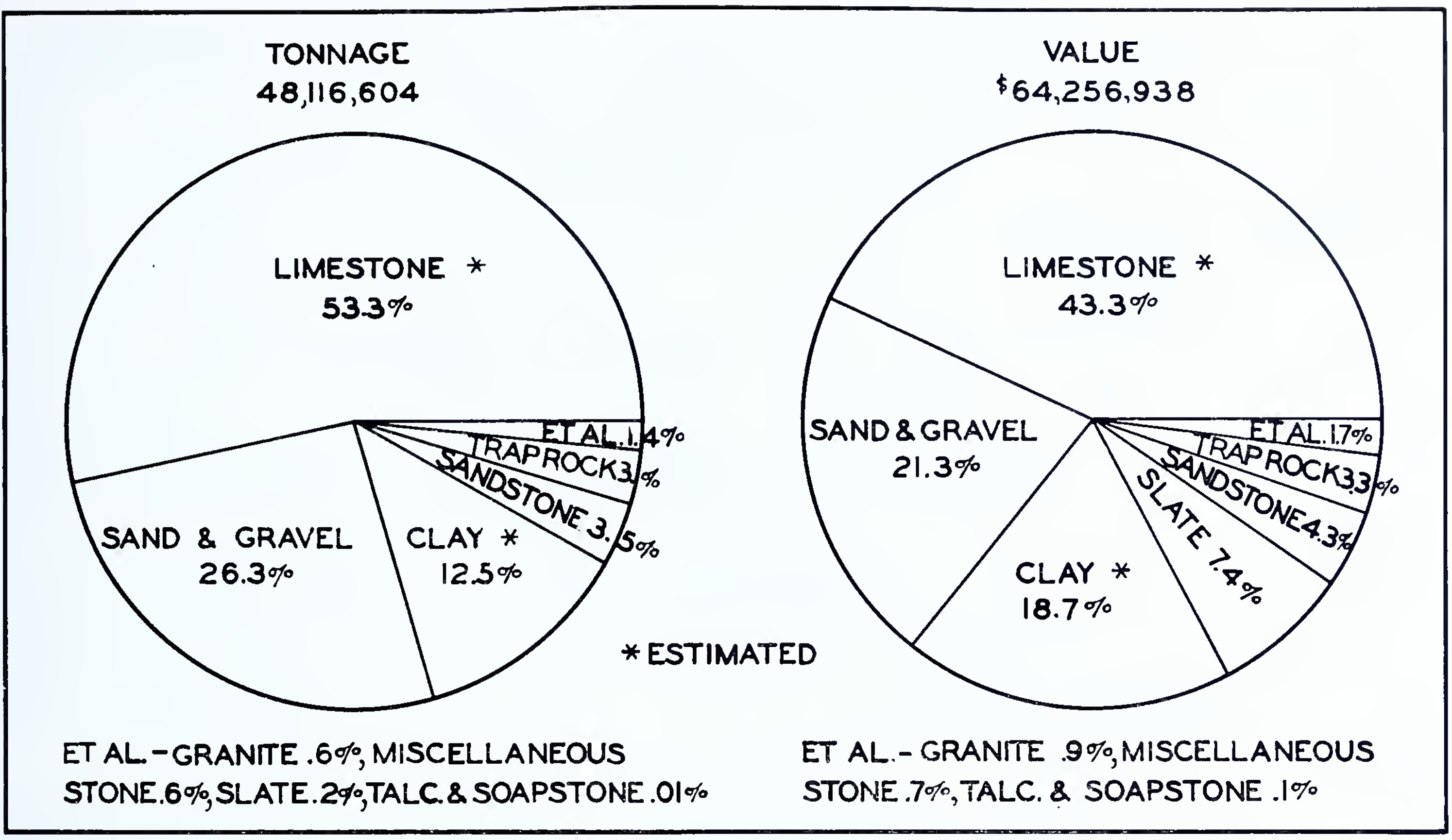

Fig. 55. Tonnage and value of the principal unprocessed rock products produced in Pennsylvania in 1929. (Based on data from Mineral Resources of the United States and on estimates by the author.)

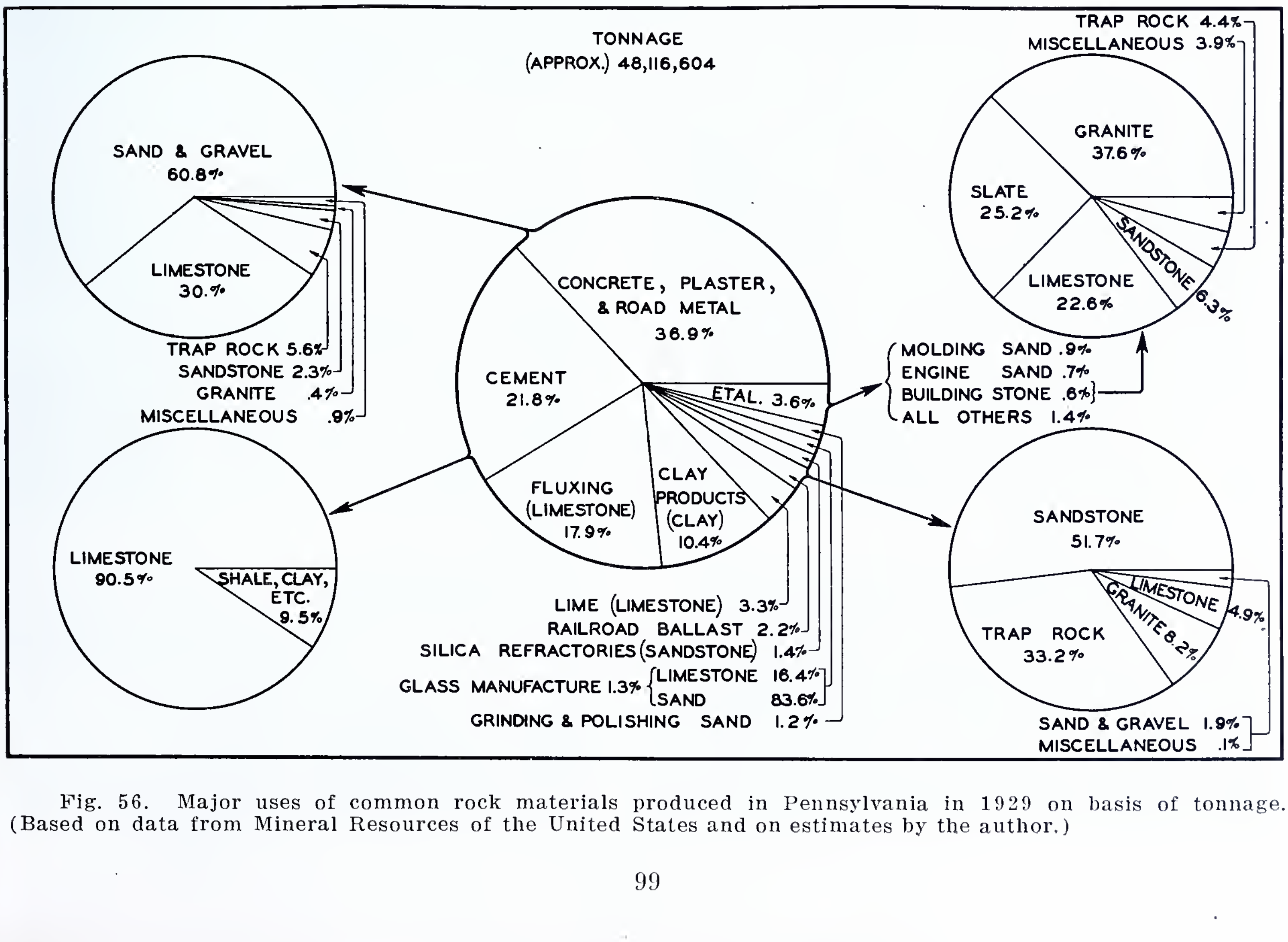

Fig. 56. Major uses of common rock materials produced in Pennsylvania in 1929 on basis of tonnage. (Based on data from Mineral Resources of the United States and on estimates by the author.)

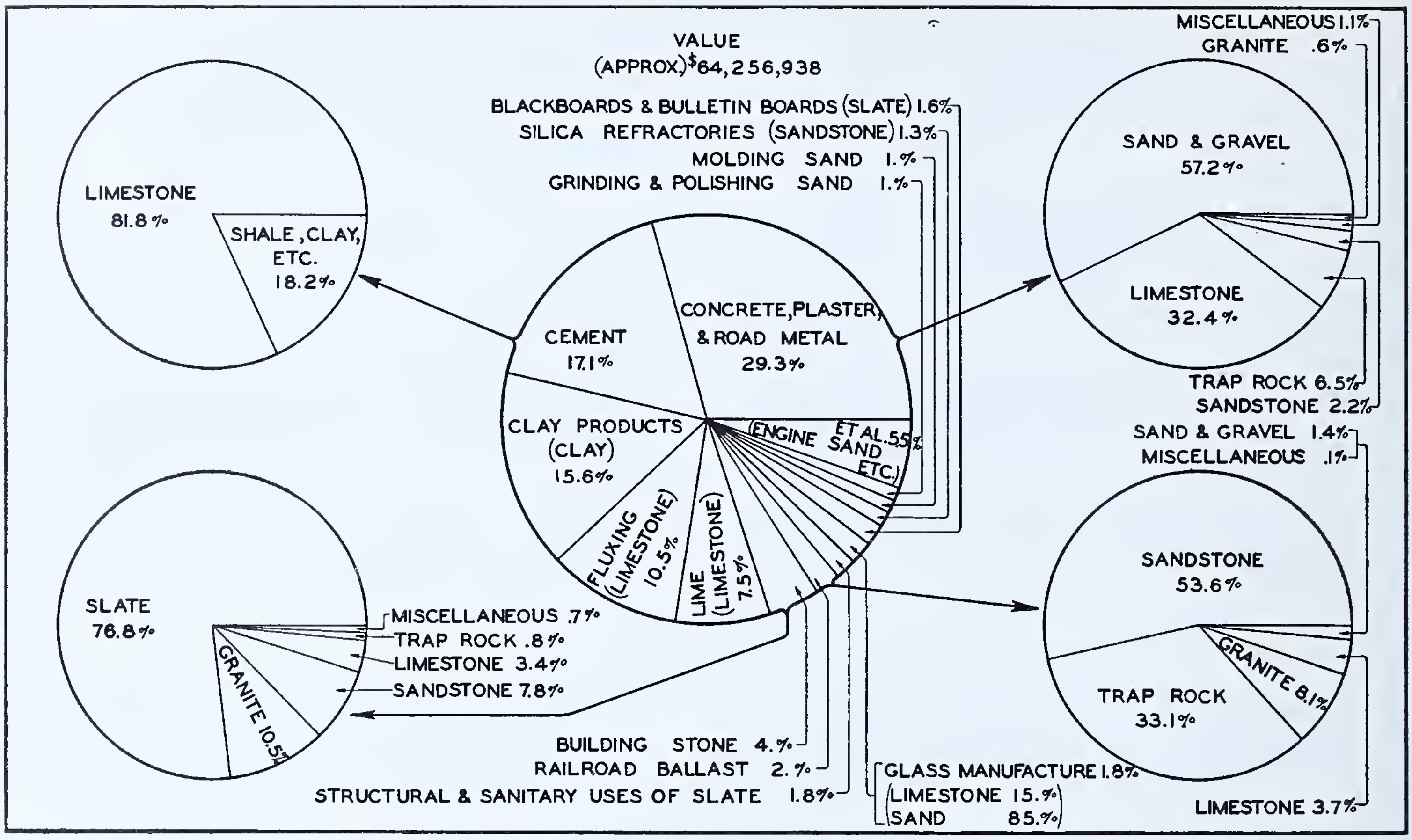

Fig. 57. Major uses of common rock materials produced in Pennsylvania in 1929 on value basis. (Based on data from Mineral Resources of the United States and on estimates by the author.)

a great number of other users account for smaller amounts.

It must be remembered that Figures 55, 56, and 57 are based in part upon estimates and doubtless fall somewhat short of representing all rock materials used. Estimates were made of the limestone and clay quarried and used direct by the cement industry and of the limestone quarried and used by the lime industry, but it is probable that a considerable amount of rock material of which there is no record is produced and used by producers. The only data available are from the reports of the United States Bureau of Mines, and it is undoubtedly true that much stone is produced which is never reported. This is particularly true of small intermittent operations. Since no other data are available, however, Bureau of Mines reports have been used as the source for most of the statistical information in the pages that follow.

The Producing Industries

Although for some rock uses no specific kind of rock is required, many other uses demand not only a certain kind of rock, but also specific chemical or physical characteristics. Thus, for lime manufacture a high-calcium limestone is required, and for building purposes a granite of a certain color may be demanded. Each rock material has its special sources, its special uses, its special problems. Hence, each of the major rock materials will be discussed separately, and these specific discussions will be followed by the discussion of some general problems.

Limestone

Limestone makes up over 50 per cent by weight of Pennsylvania's common rock products (Figure 55), amounting to approximately 25,000,000 tons annually, or more than twice as much as the tonnage of any other type of rock product. Pennsylvania is the largest producer of limestone in the United States, although its lead over Ohio and Michigan is small. In total value of limestone produced it ranks second, being outdistanced by Indiana which produces a famous building stone.

Location of Quarries.

Although limestone is fairly well distributed in Pennsylvania, it is, in general, lacking in the northern third of the State (Figure 58). The southeastern third of Pennsylvania is particularly well supplied, with the Lancaster and Chester valleys near Philadelphia producing large quantities of limestone and small amounts of crushed dolo-

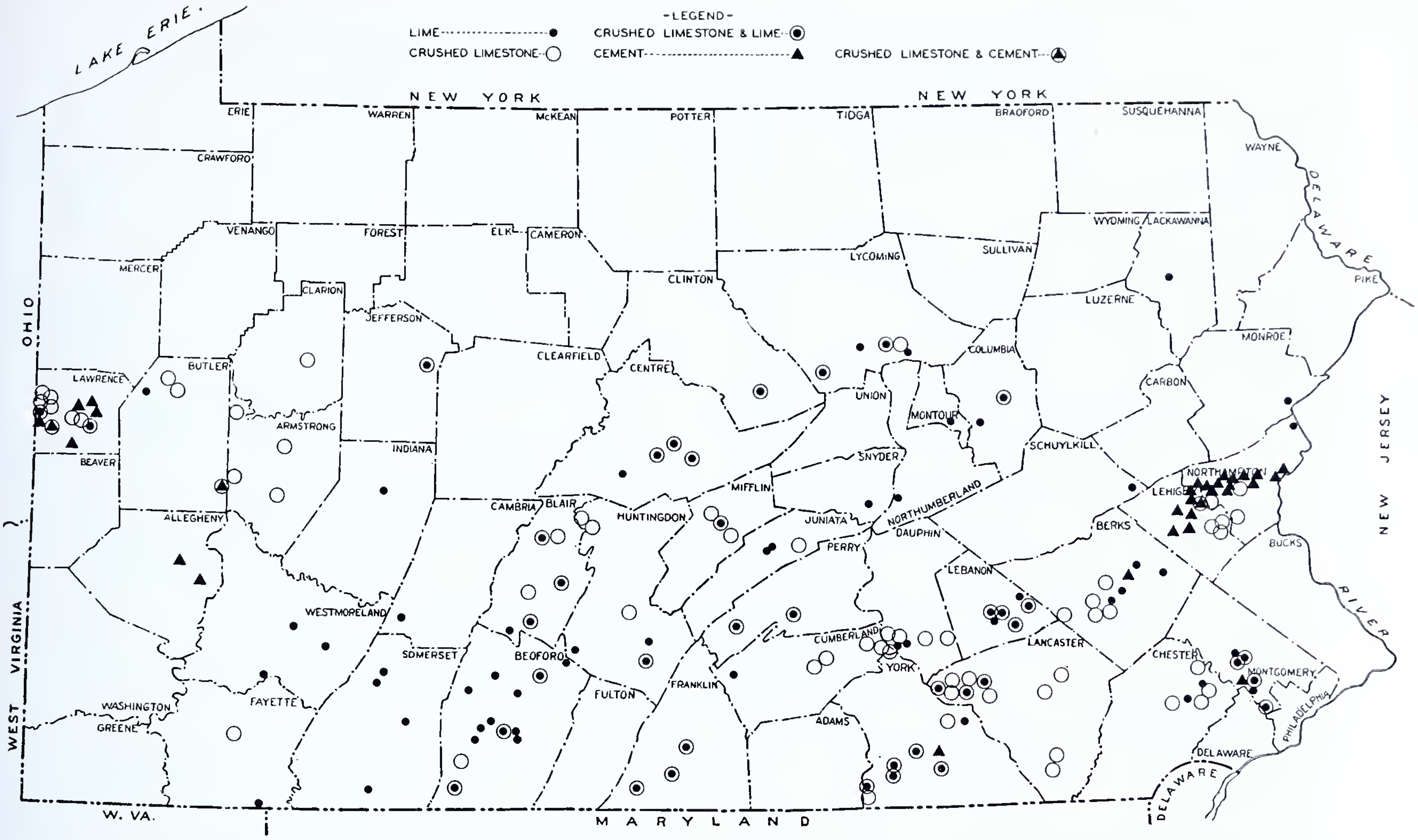

Fig. 58. Map of Pennsylvania showing limestone producers, lime plants, cement plants, etc. (Data from various directories.)

mite and marble. Also, many of the valleys of the Appalachian Ridge and Valley section of the State are floored with limestone which is suitable for lime, fluxing stone, and other uses. The limestones of the southwestern third of the State are not as abundant nor as high grade as those of southeastern Pennsylvania, but they are used to a considerable extent locally.

Mining Methods.

In most cases limestone quarries are opened in the side of a hill where tracks may be run into the quarry on a level terrace, thus facilitating the removal of the rock as it is blasted from the quarry face. Where the surface of the ground is level so that no adequate hillside location is available, it is necessary to open a pit and haul the rock up a steep incline to the plant. Occasionally, when the strata are steeply inclined as at Bellefonte, limestone is mined by sinking an inclined shaft and proceeding much as in the mining of anthracite where the pitch is steep. In western Pennsylvania, however, where narrow steep-walled valleys occur, a form of drift mining is employed, similar to that used nearby for the mining of bituminous coal.

Uses of Limestone.

Limestone is used in a great variety of ways, but, just as is true of the common rocks as a group, the great bulk of it is divided among three or four major uses (Figure 59). The largest single use made of limestone is in cement manufacture, but use for fluxing, and for concrete and road metal are of only a little less importance. Considerable amounts are used also in lime manufacture, in the making of glass, in agriculture, for railroad ballast, for rough construction work, by paper mills, and for sundry other purposes. After limestone is manufactured into lime it is widely distributed for many more uses such as for construction (mortar, stucco, and plaster); for agricultural uses; and for hundreds of chemical uses.

Value.

The average value of the limestone produced in Pennsylvania in 1929 was about $1.08 per ton. Certain uses have exacting requirements and the limestone thus used is of relatively high value—for instance, limestone for lime manufacture, for glass manufacture, or for agriculture. For fluxing and some other large-scale uses the value per ton is less than the average mentioned.

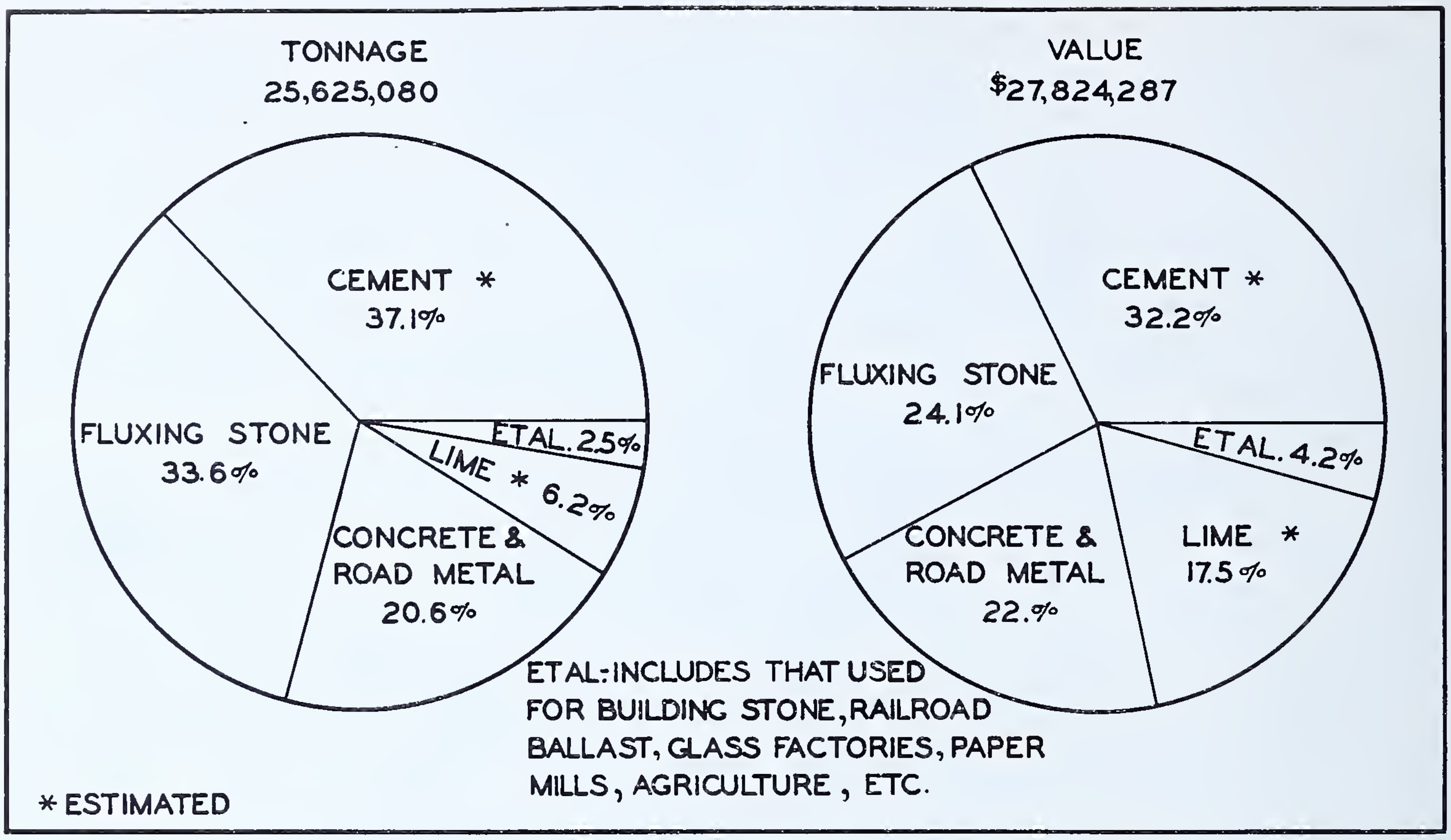

Fig. 59. Uses made of limestone produced in Pennsylvania in 1929. (Data from Mineral Resources of the United States.)

Markets.

Since each use of limestone represents a market with a definite location, limestone markets can best be discussed in terms of the major uses. The general statement may be made, however, that nearly all the limestone produced in Pennsylvania is used within the State.

Limestone Market In the Cement Industry.—The greatest user of limestone in Pennsylvania is the cement industry, located largely in the Lehigh Valley section of eastern Pennsylvania. Most of the limestone required for this industry is quarried practically at the mill sites, and is found in such large quantities that there is little likelihood of exhaustion in the immediate future. Indeed, as will be pointed out again in a later chapter, the cement industry of eastern Pennsylvania could be much extended if markets were available. In western Pennsylvania, particularly near Pittsburgh and in Lawrence County, there is a second important cement manufacturing region. Here the local Vanport limestone as well as slag is used. The actual amount of Vanport limestone which outcrops on the valley sides is not great, but by drift mining greater quantities of this stone become available, enough for many years. Pennsylvania is entirely self-sufficient in the limestone required for cement manufacture, and should continue to be so.

The Fluxing-Stone Market.—The second great use made of limestone in Pennsylvania is for fluxing stone, used mainly by blast furnaces, but also, to some extent, in steel mills. The blast furnaces of Pennsylvania are located largely along the western border of the State, in the Pittsburgh district, and at Johnstown; but some are scattered along the Great Valley from Harrisburg to Bethlehem, Pennsylvania, and along the Schuylkill River.

Chemical requirements govern very largely the choice of fluxing stone. Two types of limestone are in demand—low-silica, high-calcium limestone and low-silica dolomite. The matter of silica content is considered very important. If the limestone is to be used as a flux in blast furnaces, a silica content of about 3 per cent might be considered a reasonable upper limit. For open hearth purposes very few would care to use stone higher than 1½ per cent silica, and many are willing to pay considerably more freight in order to obtain stone with less than 1 per cent silica and preferably in the neighborhood of ½ of one per cent. For making certain classes of steel it is also essential that the fluxing stone for use in Bessemer blast furnaces be as low in phosphorus as possible.

Something like 90 per cent of the blast-furnace and open-hearth limestone used in western Pennsylvania and eastern Ohio is said to be obtained in western Pennsylvania. The limestone, which occurs quite widely in western Pennsylvania, runs from 1 to 3 per cent silica with a phosphorus content of .03 to .05 per cent. Blair County has limestone which, though it averages over 3 per cent silica, has a phosphorus content as low as .005 to .01 per cent. This low phosphorus content sometimes warrants the use of the higher-silica stone, and payment of the higher freight rate to the Pittsburgh district. Some deposits of limestone with less than 1 per cent silica occur in Centre and York counties, Pennsylvania, and in Berkeley County, West Virginia. Limestones from these districts have at times been shipped to the Pittsburgh district for open hearth use, and make up the limestone used in western Pennsylvania other than that produced locally.

Almost all of the dolomite used is for open hearth furnaces with very little as blast-furnace flux. Pennsylvania dolomites, at least those within a reasonable shipping radius of Pittsburgh, are said to be undesirably high in silica. Hence, the dolomite used in western Pennsylvania is obtained largely from Berkeley County, West Virginia, with lesser amounts from central Ohio.

> "The iron and steel plants of the eastern part of the State obtain nearly all of their fluxing limestones locally although even here material is shipped from adjoining States. For example the Bethlehem Steel Company operates a large quarry at McAfee, New Jersey, to supply high grade limestone for its Bethlehem plant."[1]

It is an interesting fact that all of the limestone used in the iron and steel industry of Sparrows Point, Maryland, comes from Adams County, Pennsylvania. The Hanover Quarry from which this limestone comes is said to be the most readily available source from which suitable stone can be obtained for the Sparrows Point industry.

Notwithstanding the fact that Pennsylvania does not supply all of the fluxing stone used within the State, the amount of such material produced is large and should continue so. Reserves seem to be adequate to supply the demand indefinitely. It is suggested that an accurate directory of the places where limestone of various grades may be obtained would be very useful.

The Concrete and Road Metal Market.—Concrete and road metal are used in all parts of the State wherever road resurfacing or construction is being carried on; and some crushed limestone has been shipped even to points outside of Pennsylvania for use in road construction. Pennsylvania has been spending more than most other States for highway construction, and consequently uses large amounts of limestone for concrete and road metal. Concrete for other types of construction finds a market chiefly in urban centers where it may be used for buildings, streets, bridges, etc.

Limestone For the Lime Industry.—Limestone used for lime manufacture must be very pure; and, since the presence of a desirable type of stone is essential, the lime kilns are frequently located where such limestones are quarried (Figure 58; see also Chapter XI, The Lime Industry).

The Building-Stone Market. — Only a small amount of Pennsylvania limestone is used as building stone, and that chiefly for rough construction (Table IX). High-grade building limestone from Indiana and marble from New England, Georgia and Alabama dominate the market for limestone for building purposes. The high value of a good limestone for building purposes may be inferred from the fact that while Indiana, home of the "Bedford" stone, produces only about one-third as much limestone as Pennsylvania, the latter's production in 1929 had a total value equal to only two-thirds of that of the Indiana production.

Agricultural Limestone.—The use of pulverized limestone and of lime for agricultural purposes is discussed in Chapter XI, The Lime Industry.

Other Markets For Limestone.—Each of the many other uses of limestone has its own areal distribution of markets, but such markets, like the building-stone market, are of little importance as to aggregate amount of limestone used.

Recent Trends in Production and Value.

Curves of the tonnage and value of limestone produced in Pennsylvania within recent years, as well as a curve of Pennsylvania's proportion of the value of limestone produced in the United States as a whole, are shown in Figure 60. Data are not available as to the exact amount of limestone used in lime manufacture or in the cement industry, although the amount is considerable, probably ten or twelve million tons at least. Hence, the curves shown are for limestone exclusive of these two items.

Production increased rapidly from 1914 until 1920. After a marked slump in 1921, a slump which affected many other commodities as well as limestone, production and value remained fair-

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[1] Miller, Benjamin LeRoy, Limestones of Pennsylvania, Pennsylvania Geological Survey, Fourth Series, Bulletin M 7, 1925, p. 344.

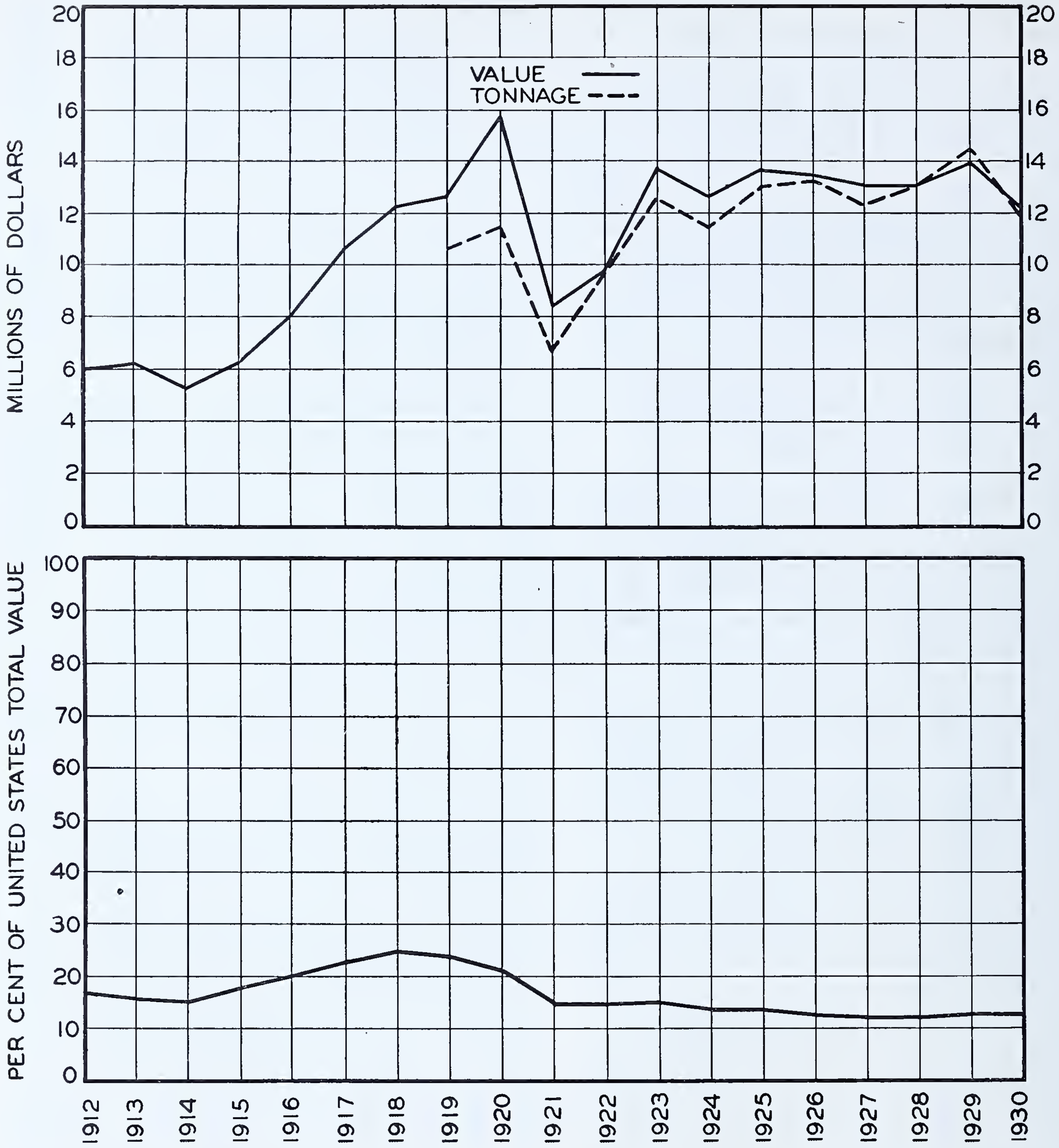

Fig. 60. Recent trends in tonnage and value of limestone produced in Pennsylvania and in the State's proportion of the United States total. (Data from Mineral Resources of the United States.)

ly steady, although they reached a slight peak in 1929 and experienced a marked drop in 1930, the latter in response to the depressed business conditions then in existence.

It was pointed out on an earlier page that Pennsylvania was outranked only by Indiana in the value of its limestone production in 1929. There has been little change in the State's proportion of the United States total within recent years, what change there has been being in the direction of a slight decline.

Tariff.

Imported limestone has for some time been subject to a tariff. Monumental or building limestone must pay 15 cents per cubic foot if in rough quarry blocks, 50 per cent ad valorem if hewn, dressed, or polished. Limestone not suitable for monumental or building uses, whether crude or crushed (but not pulverized), is subject to a duty of 5 cents per 100 pounds.

TABLE IX

BUILDING STONE (OTHER THAN SLATE) REPORTED AS SOLD OR USED BY PRODUCERS IN PENNSYLVANIA IN 1929 BY KINDS (DATA FROM MINERAL RESOURCES OF THE UNITED STATES)[a]

	Rough Constructional		Architectural		Dressed		Condition Not Specified		Totals	
	Tonnage	Value	Tonnage	Value	Tonnage	Value	Tonnage	Value	Tonnage	Value
Granite and related rocks	98,090	$224,420	5,230[b]	$38,788	3,009[b]	$6,075[c]	....	....	106,329	$269,283
Trap rock and related rocks	12,400	19,930	....	....	....	....	....	....	12,400	19,930
Limestone	64,140	87,044	....	....	....	....	....	....	64,140	87,044
Sandstone	10,700	24,432	1,899[b]	38,491	4,790[b]	136,317	....	....	17,389	199,240
Miscellaneous	....	....	....	....	....	....	11,200	$18,875	11,200	18,875
TOTALS	185,330	355,826	7,129	77,279	7,799	142,392	11,200	18,875	211,458	594,372

[a] A considerable amount of building stone of one sort or another is produced which is not reported to the United States Bureau of Mines. This is particularly true of small quarries intermittently operated and of operations consisting of gathering up of loose surface rock or float from the mountain sides. It seems probable, therefore, that many of the totals of this table are too low.

[b] Approximate.

[c] The very low value of dressed granite shown here is explained by the United States Bureau of Mines as follows: "Apparently one operator, whose activities largely influenced the small unit value shown, reported sales of dressed stone at a small value per cubic foot. This stone was not reported as dressed stone for architectural work but for heavy construction with doubtless very little work other than hand shaping."

Dolomite, Marble, and Marl.

Dolomite. — Limestone, as the word is commonly used and as it is used in this chapter, includes dolomite, a material which contains more magnesium and less calcium than true limestone. Though these two kinds of stone are not differentiated in statistical data there are certain differences in their use. For the cement industry a limestone must be low in magnesium; hence dolomite is not used for this purpose. There is a difference of opinion as to the relative values of limestone and dolomite as fluxes, and, as a matter of fact, both are used. Both dolomite and limestone are used for concrete and road metal and as building stone. For lime manufacture, of course, high-calcium limestone is desired.

In addition to these uses which dolomite shares with limestone, magnesia products made from calcined dolomite are used for fire proofing, refractory brick, furnace linings, et cetera. These will be discussed further in the chapter on "Nonclay Refractories".

Marble. — Marble, a metamorphosed limestone, occurs in southeastern Pennsylvania and is said to be produced by one quarry. The material, which has been somewhat broken by earth movements, is pulverized and sold for whiting. Marble is said to have been produced in eastern Pennsylvania in considerable quantity some 50 or 75 years ago, before the Vermont marble reached that locality, and it is possible that the industry may be extended somewhat in the future.

Marl. — Marl is a soft impure limestone of recent origin. Small deposits occur in the State, and some has been dug by shovel or scraper for local agricultural use. An attempt to dig, dry, and market this material is said to have met with difficulty owing to a tendency for the marl to gum up the grinder.

Sand and Gravel

The sand and gravel reported as produced in Pennsylvania in 1929 had a bulk of 12,674,320 short tons and a total value of $13,658,328. Sand and gravel thus ranked second (limestone first) in both tonnage and value among Pennsylvania's common rock products with 26.3 per cent of the total tonnage and 21.3 per cent of the total value. Pennsylvania ranked sixth among the States in tonnage and second in total value of its sand and gravel production (Figure 55).

Uses of Sand and Gravel Produced in Pennsylvania.

Figure 61 shows graphically the uses of the sand and gravel produced in Pennsylvania in 1929. The largest use was for building (27.2 per cent by weight of all sand and gravel was building sand, 23.4 per cent was building gravel), and this was followed by paving which used about one-third of the sand and gravel total. Then there were a great many minor uses including grinding and polishing, glass making, molding of metals, engine use, et cetera.

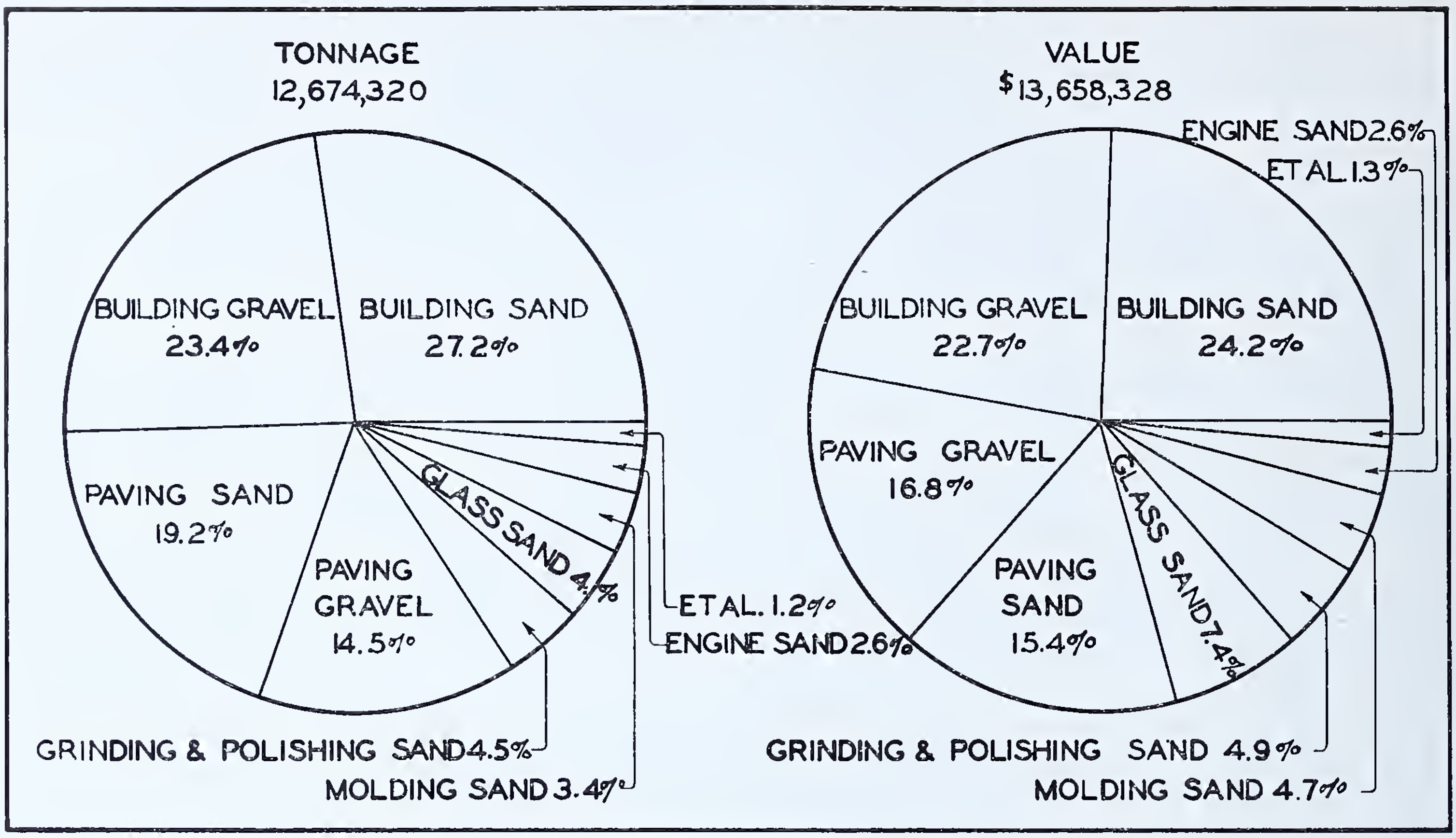

Fig. 61. Uses made of sand and gravel produced in Pennsylvania in 1929. (Data from Mineral Resources of the United States.)

Value.

The average value of the sand and gravel produced in Pennsylvania in 1929 was about $1.08 per ton, the same as the value of limestone. As in the case of limestone, there are high-grade uses which command a relatively high value per ton. Of this character are glass manufacture and molding. Sand and gravel for the bulkier uses, such as building and paving, on the other hand, come very near the average value mentioned.

Mining Methods.

The sand resulting from sand and gravel operations in the State in 1929 amounted to more than half again as much as the gravel. Part of this sand is produced directly as sand, while part is screened from sand and gravel. Most sand and gravel is scooped from pits or dredged from streams, but some special sands, glass sand for instance, although reported with sand and gravel, are really obtained by quarrying and crushing sandstone.

Location and Development of Sand and Gravel Industry.

Sand and gravel occur widely over the State (Figure 62) and over the United States. According to the United States Bureau of Mines, Pennsylvania was one of eleven States, each of which reported production from more than 100 plants and pits in 1929. Deposits suitable for specialized uses such as glass making, however, are limited in occurrence.

Building and Paving Sand and Gravel.—Sand for use in plaster, mortar for building, concrete for building and paving, and gravel for use in concrete for building and paving, may all be grouped under the heading "building and paving sand and gravel". Building and paving sand and gravel made up 84.3 per cent of the total reported sand and gravel produced. Such sand and gravel is produced from a number of widely seattered pits (Figure 62).[2] Two outstanding sources are at opposite ends of the State.

> " . . . . . On the broad flat bank of Delaware River north of Philadelphia sand and gravel are dug by great dredges floating in artificial ponds. Dippers and bucket lines work to a depth of 30 or 40 feet below the surface. The material is thoroughly washed and screened, and shipped both by boat and rail. Smaller operations using power-shovels work in these same deposits above water level. North of Easton there are sand-and-gravel pits in glacial deposits along the Delaware and at a number of places in the northeastern counties.

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[2] Sand and gravel are particularly abundant in the glaciated sections of the State, viz., in northeastern Pennsylvania and in the extreme northwestern counties. Not only are such glacial deposits of sand and gravel common in the glaciated area, but they are common, too, along streams such as the Delaware and Allegheny, which drain the glaciated area.

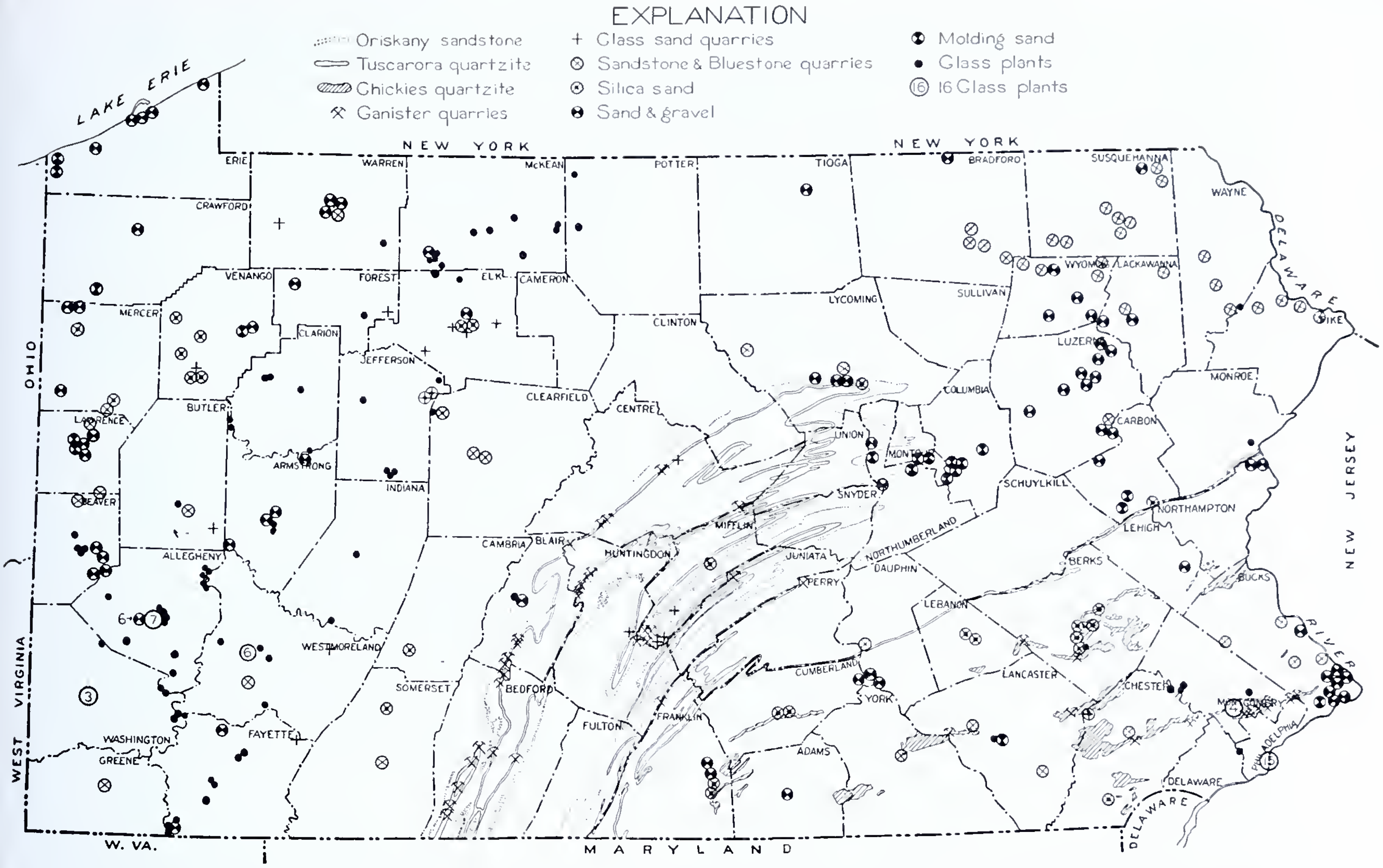

Fig. 62. Map of Pennsylvania showing sandstone and bluestone quarries, sand and gravel pits, glass plants, sources of silica sand, etc. (Courtesy of Pennsylvania Geological Survey.)

"In the west end of the State great quantities of sand and gravel are dredged from the bottom of Ohio, Allegheny and Monongahela rivers in the vicinity of Pittsburgh, and at more remote places, as Point Marion in Fayette County. Some of the largest and most modern all-electric, floating dredges in the country are operating in the Pittsburgh area".[3]

Other sources of building and paving sand and gravel are along the upper Susquehanna River in Luzerne, Wyoming, and Lackawanna counties; along the West Branch of the Susquehanna in Lycoming County; and in the glaciated counties in the northwestern part of the State, as on the shore of Lake Erie, and on French Creek near Jamesville.

Since requirements for building and paving sand and gravel are not highly specialized, such bulky material is not, ordinarily, shipped for any considerable distance; but an exception to this rule is the shipment of sand and gravel to central Pennsylvania where such deposits are generally lacking (Figure 62). For instance, Harrisburg has used much sand and gravel from the Delaware River and from Chesapeake Bay. Extensive deposits have now been opened along the Susquehanna River a few miles below Harrisburg.

"The supply of sand and gravel along the rivers in the Philadelphia and Pittsburgh districts will last for many years. Many counties in the northeastern and northwestern parts of the State are covered with a mantle of glacial deposits which constitute an inexhaustible supply for the more remote future."[4]

Glass Sand. — The common kinds of glass, such as common tableware, bottle, plate, and window glass, contain from 65 to 75 per cent silica. Although some sand with a minimum of 95 per cent silica is used in the glass industry, the best glass sand is over 99 per cent silica. Iron oxides are the most detrimental impurities of glass sand since they may cause green or yellow tints and they reduce the brilliancy and transparency of the product.

Three hundred twenty-six thousand seven hundred and sixty short tons of high-grade silica sand for glass making were produced in Pennsylvania in 1930, according to United States Bureau of Mines' figures, with a reported value of $653,607. This gave Pennsylvania a rank of third, after West Virginia and Illinois, in tonnage of glass sand produced. Glass sand amounted to 3 per cent of the total tonnage of all sand and gravel produced in Pennsylvania in 1930 and to 6 per cent of the total value of sand and gravel.

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[3] Stone, Ralph W., Pennsylvania's Nonmetallic Minerals are Worth $110,000,000 each year, Pit and Quarry, Volume 23, No. 4, 1931, p. 28.

[4] Stone, Ralph W., op. cit., p. 28.

Most glass sand produced is, in reality, friable sandstone, but, since it is crushed and used as sand, it is reported with sand and gravel and hence is discussed here.

The location of the glass sand producing industry was described by Fettke[5] a few years ago as follows:

> "At present the glass sand industry is practically confined to two parts of the State, namely: the central portion, and the western part. Of these the central area is by far the most important, both as regards the total tonnage of glass sand produced and its better quality for glass making. The productive area is confined to several localities in Huntingdon and Mifflin counties, in the vicinity of Mapleton, Vineyard, and Granville along the main line of the Pennsylvania Railroad, between Huntingdon and Lewistown. In the western part of the State the workable deposits are distributed over a much greater area, but the quality of the sandstone available is not as good as that of central Pennsylvania. In this region glass sand quarries are being operated in Elk, Fayette, Forest, Jefferson, Venango, Warren and Westmoreland counties."

Tariff. — United States producers of glass sand are protected from imported glass sand by a tariff of $2.00 per ton.

Molding Sand.—Three hundred and nine thousand five hundred thirty-three short tons of molding sand were reported as produced in Pennsylvania in 1930 with a value of $449,780. Molding sand, which is used in casting metals, is a mixture of sand and loam that will hold its shape when moist.

> "Natural bonded molding sand for casting metals is dug in considerable quantity on Delaware River above Philadelphia, on Susquehanna River near Danville and Cattawissa, along the shore of Lake Erie, and in several other places [Figure 62]. The unconsolidated deposits lying just below the sod are dug mostly by pick and shovel and loaded in wagons for hauling to the railroad cars".[6]

Silica Sand. — Silica sand of high grade, in even greater quantities than for glass, is used for grinding and polishing, for molding steel, refractory purposes, filter, and traction sand.

> " . . . . . The polishing sand is produced largely in Elk, Jefferson, Venango, Westmoreland and other counties in the western end of the State [Figure 62] by quarrying and grinding the siliceous sandstones at the base of the Coal Measure formations.
>
> "Sand from these same localities is used in molding steel castings in the Pittsburgh district. Steel plants in the eastern end of the State use sand from local rock-grinding plants or from the unconsolidated deposits in New Jersey".[7]

Recent Trends in Production and Value.

There was a general trend upward in the tonnage and value of sand and gravel produced in the State from about 1915 until 1927 (Figure 63). The years 1928, 1929, and 1930 witnessed a decrease in production, although for some reason there was a marked peak in total value in 1929.

Although ranking second among the States in the value of sand and gravel produced in 1930, Pennsylvania's percentage of the total value of sand and gravel produced in the United States has been declining slowly but steadily since about 1918.

Clay

It is believed that the first mineral industry in the State of Pennsylvania was that of digging clay to make brick in the vicinity of Philadelphia. Today, clay production and clay-products industries are of great and widespread importance in the State, and clay ranks third among the common rock industries both in tonnage and in value of production.

Since most of the clay mined is used by producers, there are no figures available regarding the total quantity of raw clay produced. One million tons of clay were sold by producers in Pennsylvania in 1929, but the total amount of clay produced in the State must have been much greater than this. The writer estimates the total quantity of clay produced in the State as about 6,000,000 short tons with a value of about $12,000,000, but there is little foundation for such an estimate.

Uses of Clay.

Although clay has almost innumerable uses, it is difficult to make any statement regarding the relative importance of these several uses as complete data are not available. Fire clay products, face brick, common brick, and pottery were the leading "clay products", by value, manufactured

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[5] Fettke, C. R., Glass Manufacture and the Glass Sand Industry of Pennsylvania, Report No. XII of Topographic and Geologic Survey Commission of Pennsylvania, 1918, p. 149.

[6] Stone, Ralph W., op. cit., p. 29.

[7] Stone, Ralph W., op. cit., p. 29.

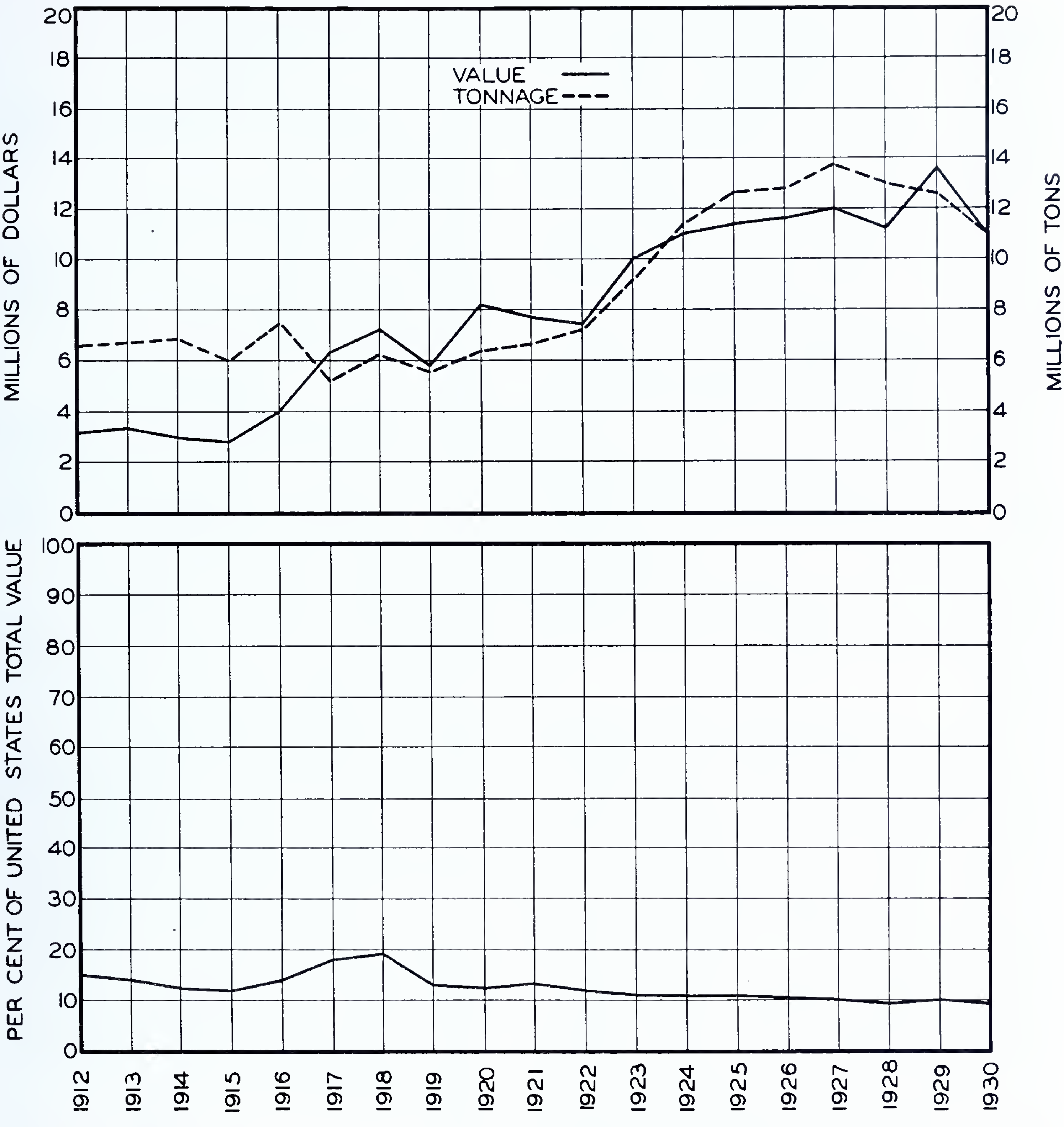

Fig. 63. Recent trends in tonnage and value of sand and gravel produced in Pennsylvania and in the State's proportion of the United States total. (Data from Mineral Resources of the United States.)

in Pennsylvania in 1929; but clay was used for a great number of other "clay products" and considerable amounts, also, were used by other industries, as in Portland cement manufacture, and for various uses outside of manufacturing.

Mining Methods.

Although pits are possible for most types of clay occurrence, drifts or shafts are usually necessary to reach fire clay. Both of these types of mining are represented in Pennsylvania.

Areas of Production in Pennsylvania.

There are few if any counties within the State which do not produce or are not capable of producing some kind of clay, but special varieties of clay for special uses are more restricted in occurrence.

Fire Clays. — Fire clays are clays which do not soften or fuse at temperatures less than 3,000 degrees Fahrenheit, and are, therefore, suitable for lining furnaces and stoves either plastered or in the form of bricks. Although such refractory uses lead, considerable quantities of fire clay are used also in the manufacture of sanitary ware, stoneware, high-grade tile, et cetera. Such clays are produced in large quantities in the State. They constituted 90 per cent of the clay mined and sold in Pennsylvania in 1930, and were probably the principal clay of the much larger total which was mined and used by producers.

Fire clay is mined chiefly in the bituminous coal area, where it occurs, ordinarily, interbedded with the coal. The best fire clay (flint clay) is mined in the eastern and northern parts of the bituminous coal area; softer clays, used for fire brick not required to meet very high temperatures, are mined farther west in Beaver and Washington counties.

Kaolin and White Clays.—Such clays occur in southeastern Pennsylvania but the production is small. They are suitable for making china or high-grade porcelain.

Clays and Shales.—Clays and shales suitable for making common brick and tile are produced in all but a few counties.

Markets.

Marketing is not a significant problem since most clay is used by producers. Some, however, is sold for use in other than mineral industries—to the paper industry as filler, to the rubber industry, et cetera—and some clay-products industries depend primarily upon purchased clay. In general, it may be said that nearly all low-grade clay products such as common brick, sewer pipe, et cetera depend upon local clay. Higher-grade products, such as china ware and porcelain, on the other hand, are of great enough value in proportion to their bulk to permit clay to be brought from a considerable distance for their manufacture. Thus, part of the kaolin needed for pottery and porcelain manufacturing is imported from England, and is able to compete in eastern Pennsylvania and New Jersey with similar clays brought a much shorter distance by rail, chiefly because of the cheapness of water transportation.

Tariff.—The tariff act of 1930 contains the following provisions in regard to clay:

"Par. 207. Clays or earths, unwrought and unmanufactured, including common blue clay and Gross-Almerode glass pot clay, not specially provided for, $1 per (long) ton; wrought or manufactured, not specially provided for, $2 per ton; bentonite, unwrought and unmanufactured, $1.50 per ton; wrought or manufactured, $3.25 per ton; china clay or kaolin, $2.50 per ton; . . . clays or earths, artificially activated with acid or other material, one-fourth of 1 cent per pound and 30 per centum ad valorem."

Shale.

Shale is the solidified and hardened equivalent of clay. It is used for much the same purposes as clay—for brick and tile manufacture, in cement manufacture, et cetera.

Clay and the Clay-Product Industries.

The chief importance of clay, of course, is as the basic material of the clay-products industries. These industries are discussed in a later chapter.

Sandstone

Sandstone ranks fourth in tonnage and fifth in value among Pennsylvania's common rock products as reported by the United States Bureau of Mines (Figure 55). Sandstone is not, however, a very important rock product, as may be inferred from the fact that, although Pennsylvania ranks first in tonnage and second in value among the States, the State's tonnage in 1929 amounted to only 1,696,290 and the value, $2,767,864. This is estimated to have been about 4 per cent of the total tonnage and 5.3 per cent of the value of all of Pennsylvania's common rock products.

Uses of Pennsylvania Sandstone.

Figure 64 shows graphically the uses to which Pennsylvania sandstone is put. The largest use (40.5 per cent by weight of the total) is for refractory stone for silica brick and furnace linings. Use for road ballast follows with 31.8 per cent of the total, then concrete and road metal with 21.4 per cent, and these are followed by a number of other uses including rubble[8], curbing, flagging, paving blocks, building stone, et cetera. The rank of the several uses of sandstone is much the same by value as it is by weight, refractory stone leading, followed by railroad ballast and concrete and road metal.

Value.

The average value of the sandstone produced in Pennsylvania in 1929 was $1.63 per ton. Among the various uses, sandstone used as building stone, or for paving blocks, curbing, or flagging has a relatively high value per ton, while for such a use as refractory stone the value is considerably below the average mentioned.

Tariff.

Sandstone producers within the United States are protected from imported sandstone which is

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[8] By use as rubble is meant use of rough stones of irregular shapes and sizes in masonry in which there is no parallelism between the rocks.

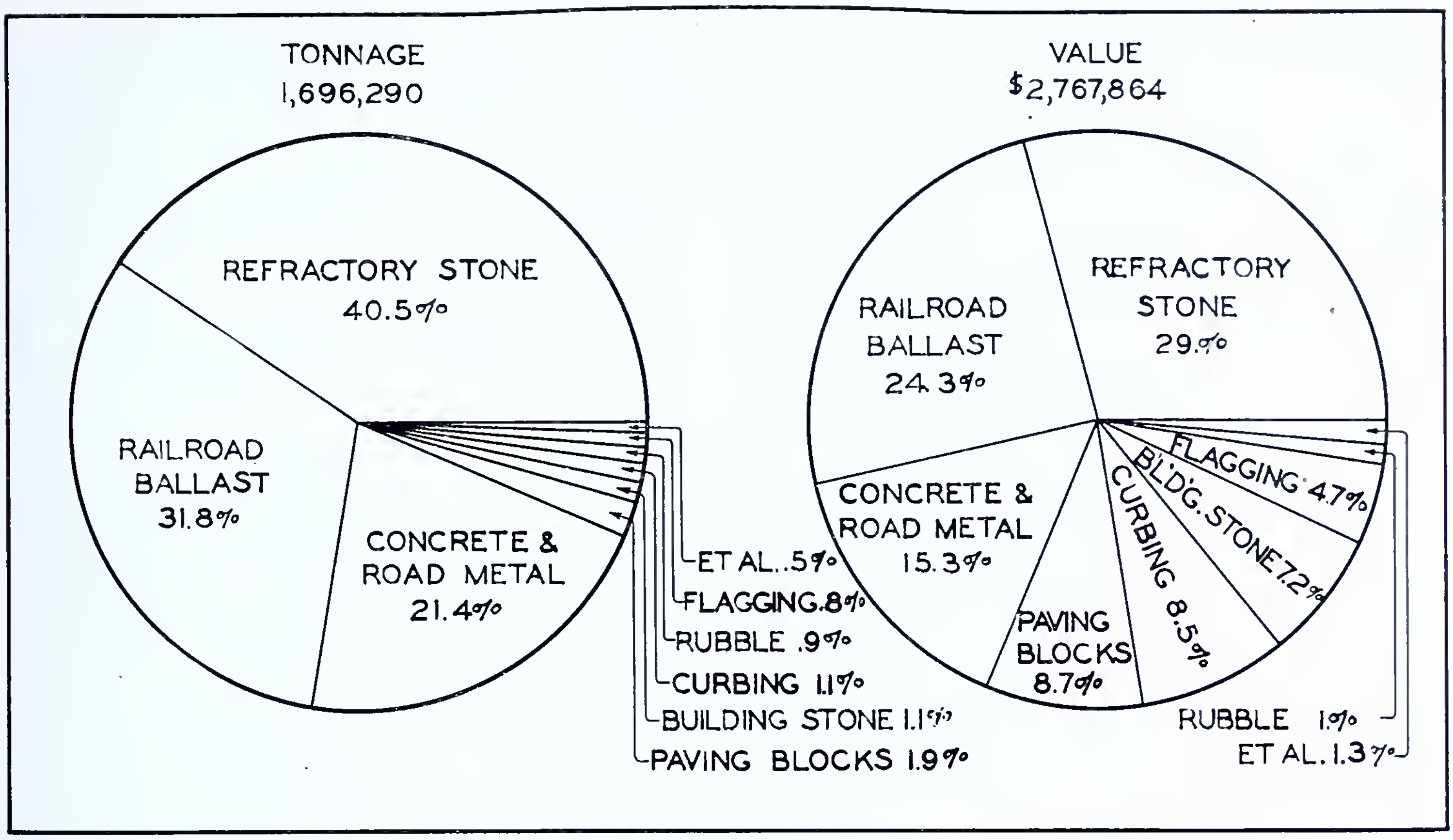

Fig. 64. Uses made of sandstone produced in Pennsylvania in 1929. (Data from Mineral Resources of the United States.)

suitable for monumental or building stone by a tariff of 15 cents per cubic foot on rough quarry blocks and 50 per cent ad valorem on the hewn, dressed, or polished product. All other sandstone may enter the country free.

Varieties of Pennsylvania Sandstone.

Sandstone as here used includes bluestone and ganister as well as ordinary sandstone.

Bluestone.—Bluestone is a variety of sandstone which occurs in northeastern Pennsylvania and in New York, which, because of the character of its bedding, is quarried for flagging and curbing. About 19,520 short tons of this stone (included in sandstone totals above) were quarried in Pennsylvania in 1929, valued at $212,090. This was about 1 per cent by tonnage and 8 per cent by value of the total sandstone production of the State. Pennsylvania ranked second to New York in bluestone production, the latter's production being 46,480 tons valued at $571,845.

Fifty-nine per cent of Pennsylvania's bluestone production (by value) was used for flagging, 31½ per cent for curbing, 9 per cent for building stone, and the remaining fraction of one per cent was used for miscellaneous purposes.

The bluestone quarrying industry is located in the northeastern corner of the State in Susquehanna, Wayne, and adjacent counties (Figure 62). Methods of quarrying are somewhat obsolete. Most of the drilling is still done by hand, and wedges are used to spring the holes.

Though an industry of long standing, bluestone quarrying was for a time greatly reduced by the increasing use of Portland-cement concrete. During the last five or six years, however, there has been a revival in demand for natural stone, and this has stimulated the industry.

> " . . . . . The heavy stock is used for ashlar, sills, platforms and other places having transverse strain, common flags are now finding a market for walks and floors, both interior and exterior, in large institutions, public buildings, and private estates, and the very thin flags are now made into roofing shingles, wall panels, and tile to be set in cement. Flagging is also used for base-boards. Broken or irregular slabs, formerly waste, now are sold by the ton for garden paths . . .
>
> "One mill, at Meshoppen, Wyoming County, furnishes flags with natural or rubbed surface, in a variety of tones of red, blue, green and gray, and in any size from tile 1 foot square to flags for stair landings 7 feet by 9 feet and finished on both sides."[9]

Ganister.—The broken blocks of sandstone and quartzite which form the lower slopes of many mountain sides in Pennsylvania are referred to as "ganister". This material consists almost entirely of grains of quartz.

Though long unused, ganister now forms the basis for a considerable industry. It is used in making silica brick for metallurgical furnaces, lime and cement kilns, and coke ovens, where a highly heat-resistant material is needed.

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[9] Stone, Ralph W., op. cit., p. 33.

In 1930 Pennsylvania's output of ganister was about 483,160 short tons or 68 per cent of the United States total. It made up 33 per cent by weight of Pennsylvania's total sandstone production, and had a value of $600,100, twenty per cent of the total value of sandstone produced in Pennsylvania. The ganister is produced in the mountains of central Pennsylvania and in several areas in the southeastern counties of the State.

Methods of production are particularly simple on the lower mountain slopes.

> "Because the rock on these flows is broken and loose the principal requirement for harvesting it is a light railroad. As the floes lie at a high angle, a light track with switch-backs makes all parts accessible and the rock up to 2-man size can be loaded by hand. Some of the larger blocks may be broken by explosives before loading. The whole operation is one of stripping the surface of the suitable rock by hand selection and loading. When one area is stripped the track may be moved to another floe or, if the distance is too great, the ledge from which the stone was broken by nature's forces may become the site of a quarry."[10]

A schist quarried in Montgomery County is used, like ganister, for refractory purposes. It may be used in thin slabs for hearth lining, or may be crushed.

Other Sandstone and Quartzite.—Other sandstone and quartzite quarries are scattered widely over the State and produce stone for a variety of purposes.

> "Building stone sold as rubble, riprap and cut stone is produced in largest quantity at Koppel and Wurtemburg near Ellwood City in Beaver County, Neshannock Falls in Lawrence County, and Curwensville, Clearfield County. These quarries furnish a gray to tan or buff sandstone in blocks of any desired size up to those weighing 2 or 3 tons each for bridge masonry. The output of these quarries north of Pittsburgh is shipped as far east as Philadelphia. The Homewood sandstone of the Pottsville formation is the geologic horizon most used. Large quantities of curbstone are made at Koppel and Wurtemburg for the Pittsburgh district. Curbing is cut also from the Connoquenessing sandstone at Madera, Clearfield County, and from the red Chemung sandstone on Lehigh River near White Haven, Luzerne County.
>
> "Red Triassic sandstone or brownstone is no longer quarried extensively for building stone in this State, the large operation at Hummelstown having been discontinued in 1928 for lack of demand. Lighter-colored stone is preferred.
>
> "Sandstone and quartzite rubble for building purposes is produced in other parts of the State but only in small quarries. Some very attractive and durable stone that dresses well to ashlar of variegated color is taken from fields of float on Kittatinny and other mountains without quarrying."[11]

Some of the quartzites of central Pennsylvania are popular locally for building purposes. The Tuscarora quartzite, for example, has a white to pinkish color which is particularly agreeable, and it is an exceedingly durable stone. Quartzite is difficult to work, which handicaps it in competition with the other building stones. The use of the Tuscarora quartzite is now principally local, but the quantity of this stone available is great, and it would seem that the possibilities of extending its markets as a building stone should be worth investigation.

Recent Trends in Production and Value.

With only temporary interruptions (as in 1921) there has been a steady rise in the value of sandstone produced in Pennsylvania since about 1915 (Figure 65). The curve of total tonnage begins with 1920, since no tonnage figures are available for earlier years. It shows the same 1921 slump observable in the value curve, and, following that, an only slightly interrupted rise until 1929. Total tonnage decreased in 1930 in spite of an increase in total value produced.

It has been pointed out that Pennsylvania ranks second among the States in the value of its sandstone production. From about 34 per cent of the total United States sandstone value in 1918, Pennsylvania's proportion declined to 20 per cent in 1925. In 1930, it had risen to 29 per cent, just a fraction of 1 per cent behind Ohio which led in value of production. Pennsylvania's sandstone tonnage was more than three times as great as that of Ohio.

Trap Rock and Granite

Two main classes of igneous rocks are quarried in Pennsylvania—the fine-grained types commonly referred to as "trap rock", and the coarser-grained varieties which may be designated as "granite and related rocks". The occurrence and production of both groups of rocks is confined to a few counties in the southeastern corner of the State.

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[10] Stone, Ralph W., op. cit., p. 34.

[11] Stone, Ralph W., op. cit., pp. 32-33.

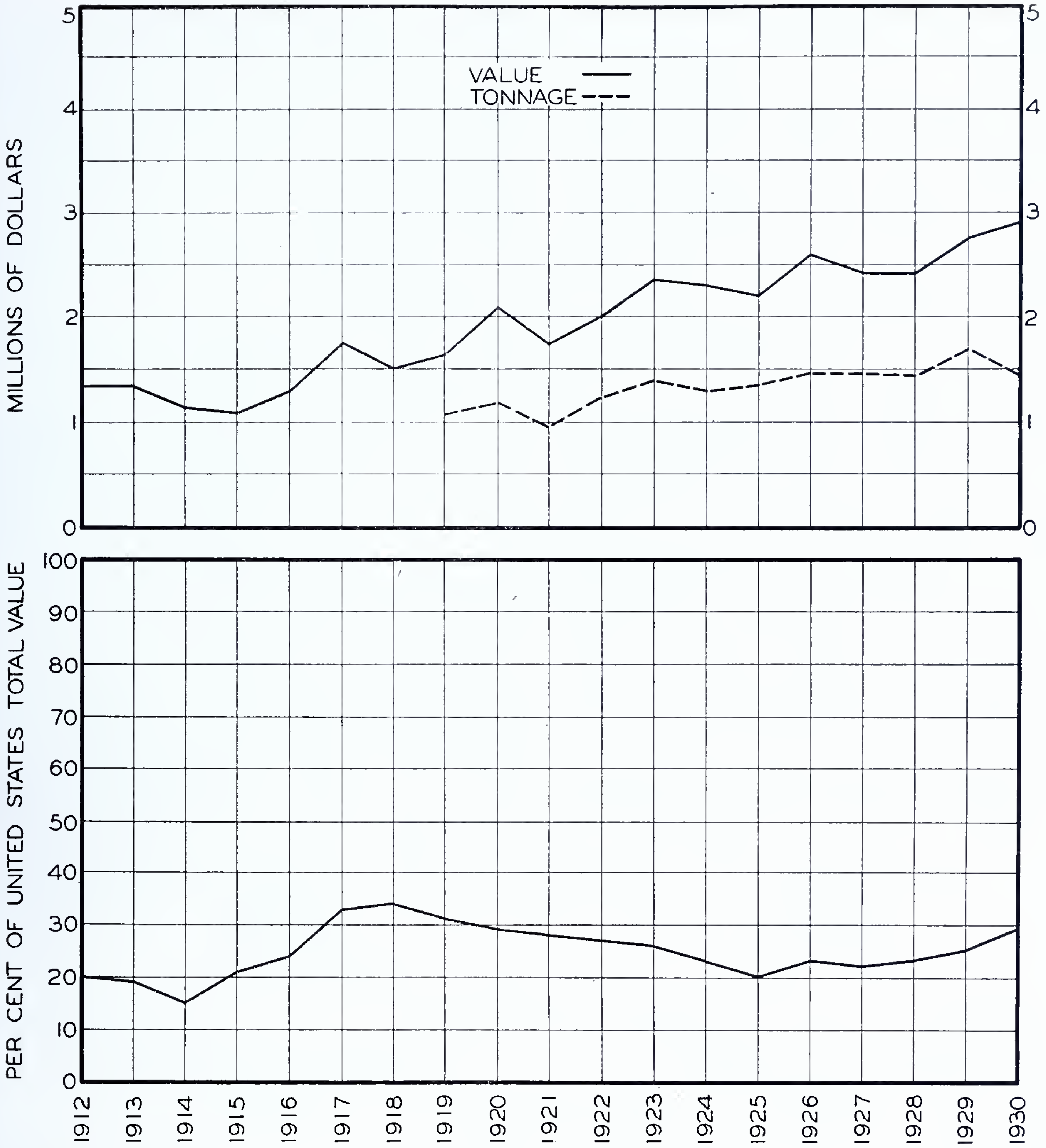

Fig. 65. Recent trends in tonnage and value of sandstone produced in Pennsylvania and in the State's proportion of the United States total. (Data from Mineral Resources of the United States.)

Trap Rock.

The principal material classed as trap rock in Pennsylvania is a hard, black rock frequently called "black granite", occurring near Gettysburg and extending northeastward in an irregular strip to just south of Lebanon, and in irregular areas farther northeast, principally in southern Berks County and adjacent parts of Montgomery and Lancaster counties, in northern Montgomery County, and northwestern Bucks County.

"This hard black rock meets all the requirements of the Pennsylvania Department of Highways and is used extensively for road metal; also for aggregate in concrete for general building purposes. One quarry near Birdsboro has a production capacity of 4,000 tons daily, and one near Quakertown about 3,000 tons. This stone also makes excellent paving blocks. Although it is durable and can be dressed to ashlar, it is little used for building stone because the color is so dark that it makes a somber building. The effect can be lightened by extra wide and white mortar joints".[12]

Lighter colored (frequently red or green) rocks commonly classed with trap occur in South Mountain and are extensively ground for making roofing granules.

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[12] Stone, Ralph W., op. cit., p. 31.

Trap rock and related rocks quarried in Pennsylvania in 1929 are reported by the United States Bureau of Mines to have had a tonnage of 1,443,610 and a value of $2,143,164. They thus amounted to a little over 3 per cent by bulk and about the same per cent by value of all unprocessed rock products of the State (Figure 55). Pennsylvania ranked fifth in the production of trap rock in terms of tonnage with about 10 per cent of the total United States production, and fourth in value with 11 per cent of the total.

Two-thirds of the State's total production by weight was used as concrete and road metal; railroad ballast, the second use in importance, accounting for about one-fourth of the total (Figure 66). In terms of value, about 57 per cent of the State's total was used for concrete and road metals; about one-fifth was used for railroad ballast; and another fifth was for "other uses", chiefly the making of roofing granules. Only about 1 per cent (by value) was used as building stone and this altogether for rough construction.

"Black Granite" for Monuments.—Three quarries in southeastern Pennsylvania are being worked for "black granite" monument stock. This material is trap rock, but because of its trade name it is classified with granite by the United States Bureau of Mines. It must be remembered, therefore, that the "trap rock" discussed above and displayed in Figures 66 and 67 is in reality trap rock other than that sold as "black granite" for monumental purposes, and that the figures for "granite and related rocks" given in later paragraphs and in Figures 68 and 69 really include monumental trap rock which is called "black granite" by the trade.

"'Black granite' or diabase is quarried at Coopersburg and Saint Peters and polished for monument stock. The highly-polished black surfaces of this fine-grained granitoid stone show carving well and are highly resistant to weathering. This polished stone sawed in slabs would be suitable for exterior and interior paneling in office buildings, banks, etc. The Shakespeare Memorial in front of the Free Public Library on Logan Circle, Philadelphia, is made of this 'black granite.' ".[13]

Pennsylvania "black granite" for monumental purposes meets competition toward the northeast from New England granites. It meets competition, too, from rough monumental granite imported from Sweden. The United States Tariff Commission which investigated this competition some years ago found that at New York City, the principal point of competition between rough monumental "black granite" from Pennsylvania and

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[13] Stone, Ralph W., op. cit., p. 30.

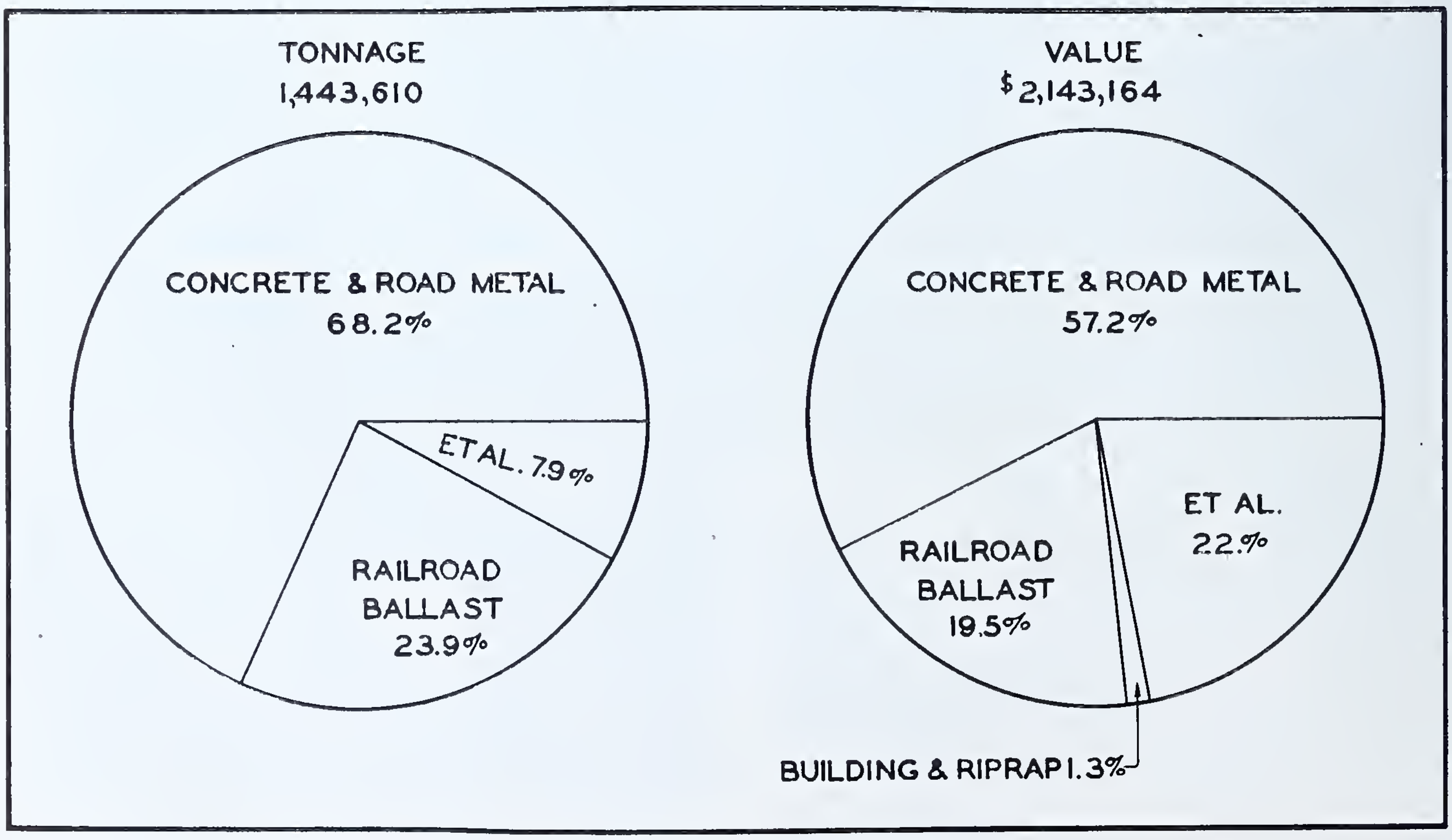

Fig. 66. Uses made of trap rock produced in Pennsylvania in 1929. (Data from Mineral Resources of the United States.)

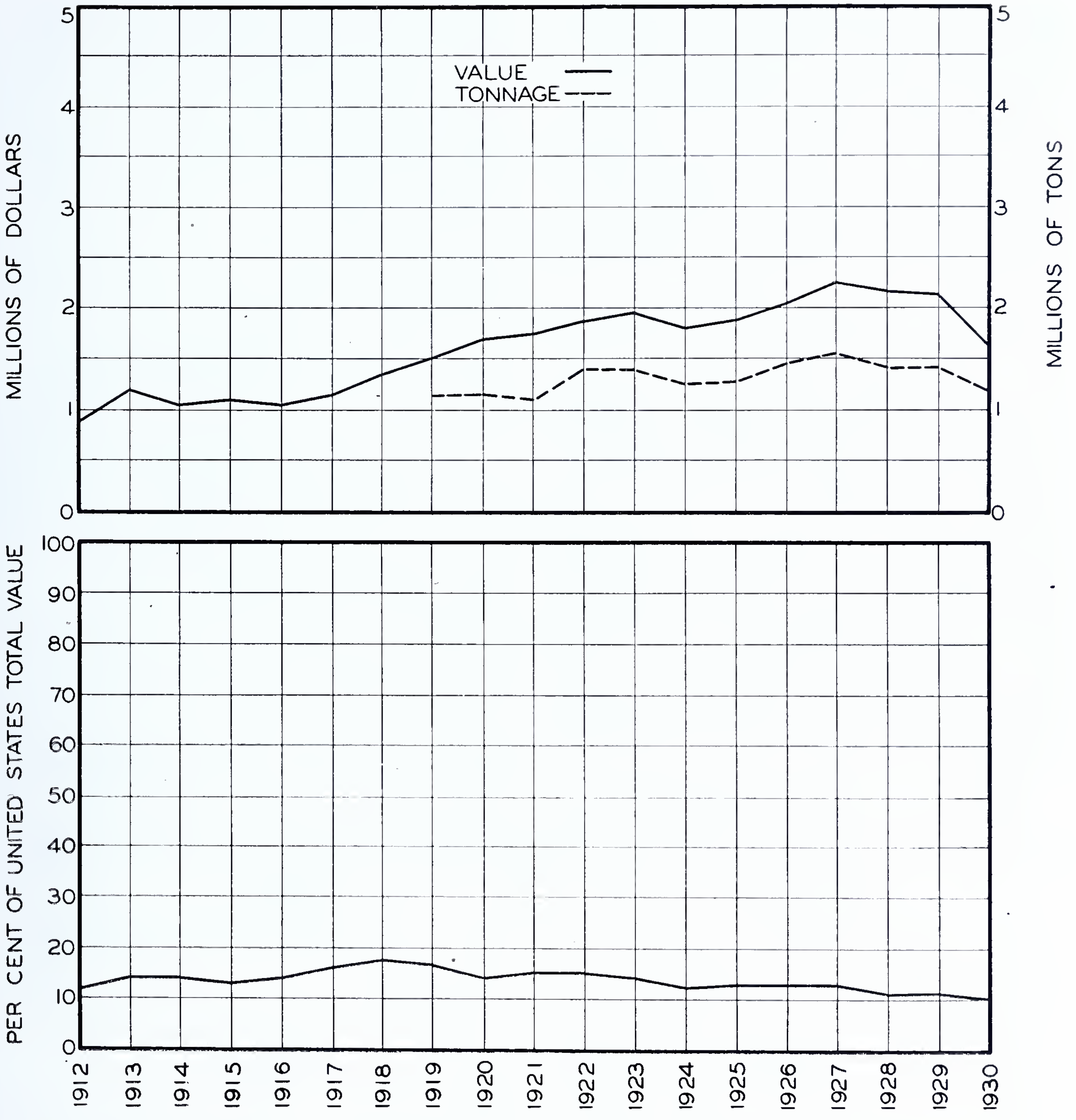

Fig. 67. Recent trends in tonage and value of trap rock produced in Pennsylvania and in the State's proportion of the United States total. (Data from Mineral Resources of the United States.)

the Swedish unmanufactured monumental granite, the cost to the importer was higher than the cost of Pennsylvania "black granite" delivered at the same point.

Recent Trends in Production and Value.—After a long period of increase with but temporary interruptions, both the tonnage and the total value of trap rock produced in Pennsylvania reached peaks in 1927 (Figure 67). A decline then began which became particularly marked in 1930.

In its proportion of the total value of trap produced in the United States, Pennsylvania has shown a gentle but continuous decline since 1918.

Granite and Related Rocks.

Granite and related rocks are less important both in tonnage and value than trap rock in Pennsylvania. These relatively coarse-grained igneous rocks, including granite, various kinds of gneisses, schist, gabbro, et cetera, are, like trap rock, confined to the southeastern corner of the State. There they occur in a belt extending from southern York County to southern Bucks County, and in irregular areas in northern Chester County, and in Berks, Lehigh, and Northampton counties. Quarries in these rocks are numerous.

" . . . . . Most of them [the quarries] are producing rough building stone and the number of stone houses in some neighborhoods is notable. Mica schist and the various gneisses in the immediate vicinity of Philadelphia make excellent building stone and their durability is attested by small churches that were erected as early as 1715 and are still in use.

"Swarthmore and Bryn Mawr Colleges and many other institutions near Philadelphia are built of the local mica gneiss, and of granite gneiss, which differs from granite only in that the minerals have a banded arrangement. Washington Memorial Chapel at Valley Forge is granite gneiss from Holmesburg, in Philadelphia, where a large quarry has been developed to a depth of 100 feet.

"Many of the building-stone quarries are comparatively small and of intermittent operation, but some, like the Leiper quarry near Swarthmore have been operated more than 100 years and have attained sizable dimensions. Crushed-stone quarries in these rocks range all the way from small ones operated by portable machinery for a single job to those capable of a large daily output. A quarry in gabbro at Glen Mills, Delaware County, during the present period is shipping 1,300 tons daily from a completely-electrified modern crushing plant.

"Granite for use largely in churches and schools is quarried in South Mountain between Reading and Allentown. Some of it has a reddish color, takes a high polish, and might be used for monuments except that the color is irregular in distribution. This feature is inconspicuous in rubble and rock-face ashlar."[14]

The United States Bureau of Mines reported a Pennsylvania granite production for 1929 of 285,540 tons with a value of $598,912. Granite thus amounted to about .6 of one per cent by weight and .9 per cent by value of all unprocessed rock products of the State (Figure 55). Pennsylvania ranked ninth in tonnage and fourteenth in value among the States in granite production.

Over one-third of Pennsylvania's product by weight was used for building purposes (See Table IX, page 105), about 30 per cent for railroad ballast, one-fourth for concrete and road metal, and the remaining nine or ten per cent for paving blocks, curbing, monumental use, miscellaneous building use, et cetera (Figure 68). When calculated on a basis of value, concrete and road metal and railroad ballast are somewhat less important than on a weight basis. Thirteen and eight-tenths per cent of the total value is represented by monumental stone, part of this being the "black granite" referred to in an earlier paragraph.

Recent Trends in Production and Value.—Unlike its production of many of the other rocks,

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[14] Stone, Ralph W., op. cit. pp. 29-30.

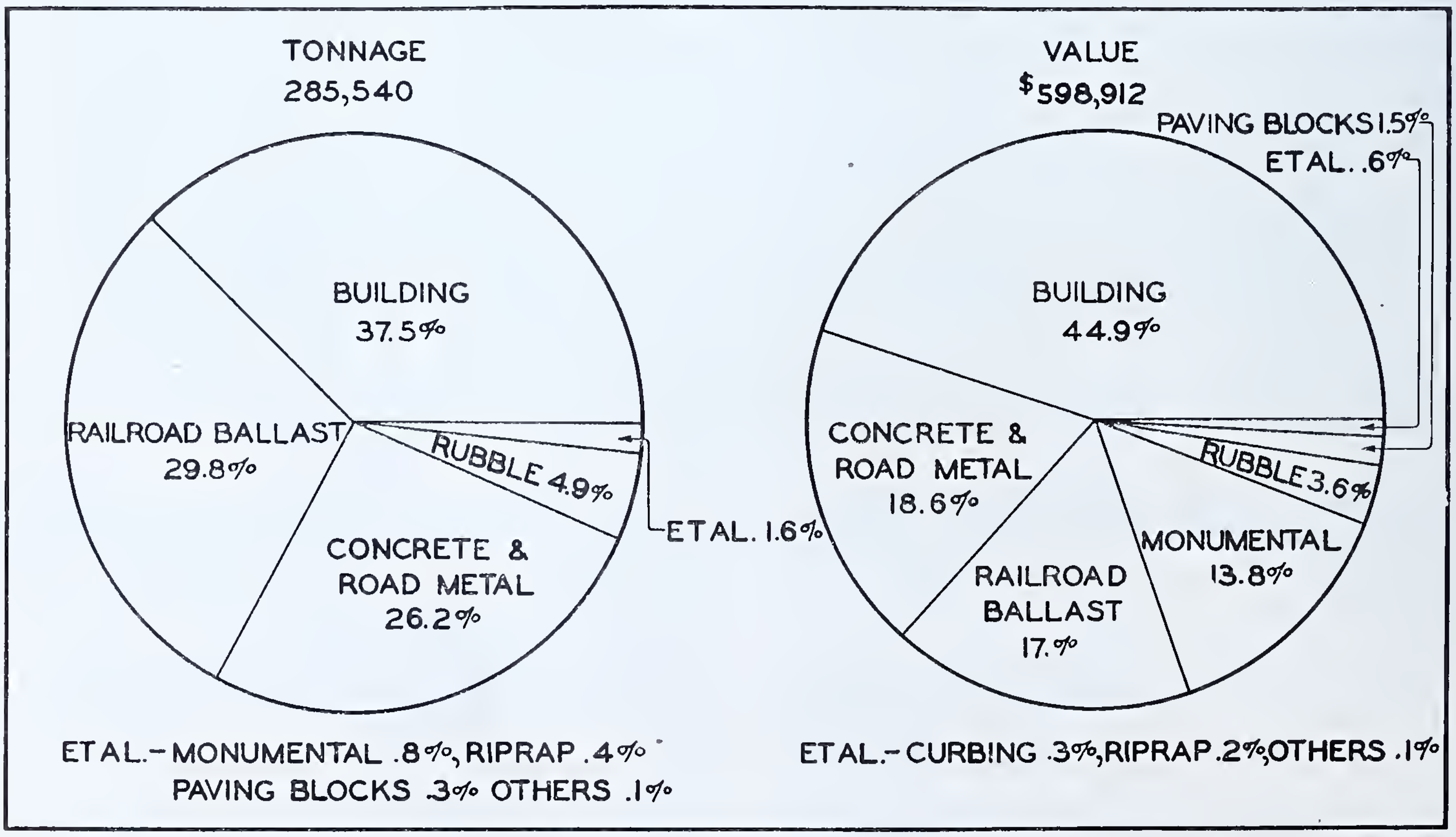

Fig. 68. Uses made of granite produced in Pennsylvania in 1929. (Data from Mineral Resources of the United States.)

Pennsylvania's granite production reached its lowest ebb for several decades in 1917 (Figure 69). From 1917 until 1927 production and value increased with only temporary interruptions. Like trap rock and several of the other common rock products, granite suffered a decline both in production and value in 1928 and succeeding years in response to generally poor market conditions.

In its proportion of the total value of granite produced in the United States, Pennsylvania has varied little for a number of years, although its percentages for 1929 and 1930 were slightly lower than those for any preceding year since 1921.

Tariff.

Granite which is suitable for use as monumen-

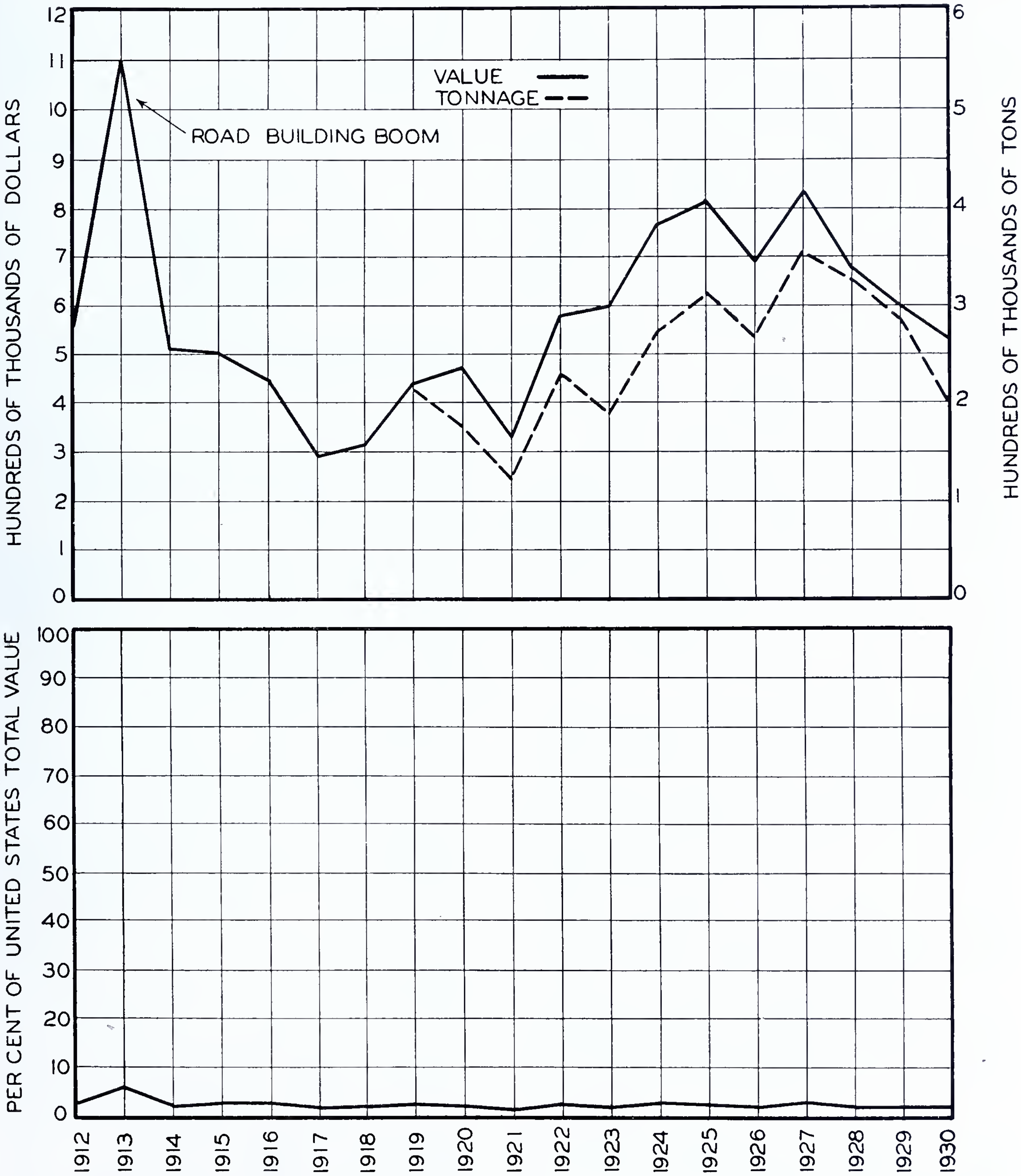

Fig. 69. Recent trends in tonnage and value of granite produced in Pennsylvania and in the State's proportion of the United States total. (Data from Mineral Resources of the United States.)

tal, paving, or building stone if hewn, dressed, pointed, pitched, lined, or polished is subject to a tariff of 60 per cent ad valorem; if unmanufactured, 25 cents per cubic foot. All other granite and all trap rock enters the United States duty free.

Slate

The tonnage of slate quarried each year in Pennsylvania is small when compared with tonnages of limestone and of sand and gravel, slate totalling only about two-tenths of one per cent of the common rock products (Figure 55). It is, therefore, less important on the basis of weight than any of the other rock materials thus far considered. In total value, slate ranks fourth among the common rock materials, being exceeded only by limestone, sand and gravel, and clay. It seems still more important when one considers that Pennsylvania ranks first as a producer of slate with an output of nearly 51 per cent (by value) of the United States total. Vermont, producing 27.5 per cent of the country's total, is Pennsylvania's closest competitor.

Location of Production in Pennsylvania.

"Of Pennsylvania slate districts there are three [Figure 70]. (1) that which borders on Maryland at the south, lying in Lancaster and York counties, and is a portion of the Peach Bottom district; (2) that centering around Slatington and Danielsville, the greater part of which lies in Lehigh County; and (3) that which lies wholly in Northampton county and centers about Pen Argyl and Bangor, with other quarries to the south, near Bath and Nazareth."[15]

Methods of Mining.

As a rule, slate is quarried by digging deep pits in the ground, pits which in some cases are over 500 feet in depth. Very little slate is mined by underground methods, although at Delta, near the Maryland line, an underground mine was opened, but is now abandoned. Slate quarrying gives rise to large piles of waste rock[16] which are cumbersome and difficult to dispose of. Many quarrymen make use of old and abandoned pits for storing the waste material.

During recent years the slate industry has made rapid strides in improving the technique of quarrying and manufacture. A notable example of this has been the substitution in Pennsylvania of wire saws for channeling machines in making the primary cuts in quarries.[17] This is said to have proved a great advantage in reducing waste, saving time, and reducing production costs.

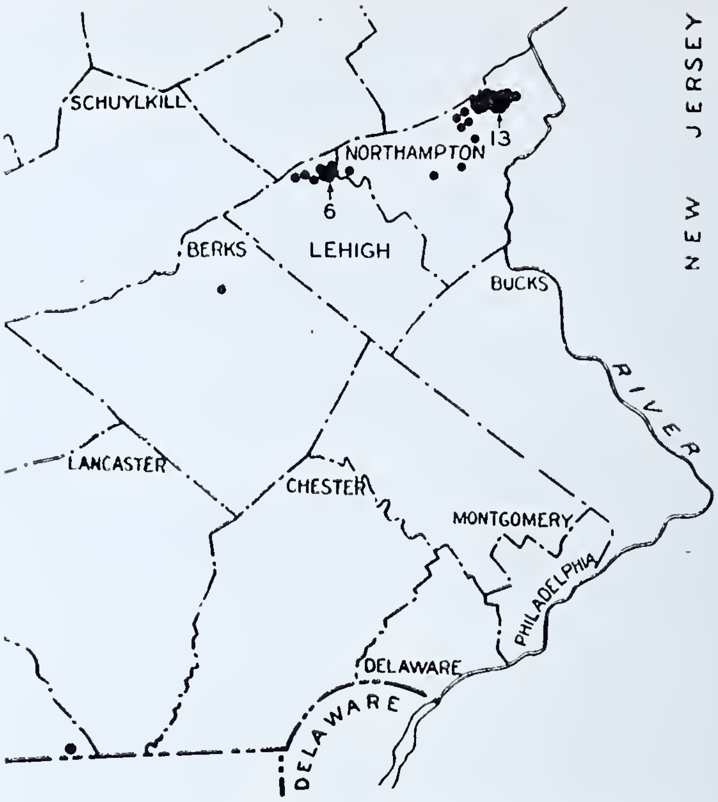

Fig. 70. A portion of southeastern Pennsylvania showing principal slate quarries, 1929. (Locations from Mineral Resources of the United States.)

The Uses of Slate.

The largest use made of slate is for roofing, 42.3 per cent by weight of the total slate sold in Pennsylvania in 1929 and almost an equal per cent by value being for this purpose (see Figure 71). The second largest use is for structural and sanitary purposes which consumed 12.9 per cent of the total (by weight). Under this heading is included slate used for toilet appliances, shower stalls, sinks, tubs, grave vaults, vats, shelving, copings, hearths, billiard tables, stairs, tables, and lithographic stone. About half as great in tonnage as the slate used for structural and sanitary purposes was that used for blackboards and bulletin boards. Still smaller in quantity, 1.4 per cent of all slate produced in the State in 1929, was slate for electrical switchboards. This highly specialized use requires a slate low in carbon and iron-bearing minerals.

Slate may be crushed to a granulated form and employed in the manufacture of slate-surfaced composition roofing. Many different colors are used, and experiments are being made in the use

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[15] Behre, Charles H., Jr., Slate in Northampton County, Pennsylvania, Pennsylvania Geological Survey, Fourth Series, Bulletin M 9, 1927, p. 295.

[16] In some quarries this waste amounts to 75 per cent of the total rock quarried.

[17] Bowles, Oliver, and Coons, A. T., Slate in 1929, Mineral Resources of the United States, 1929—Part II, p. 63.

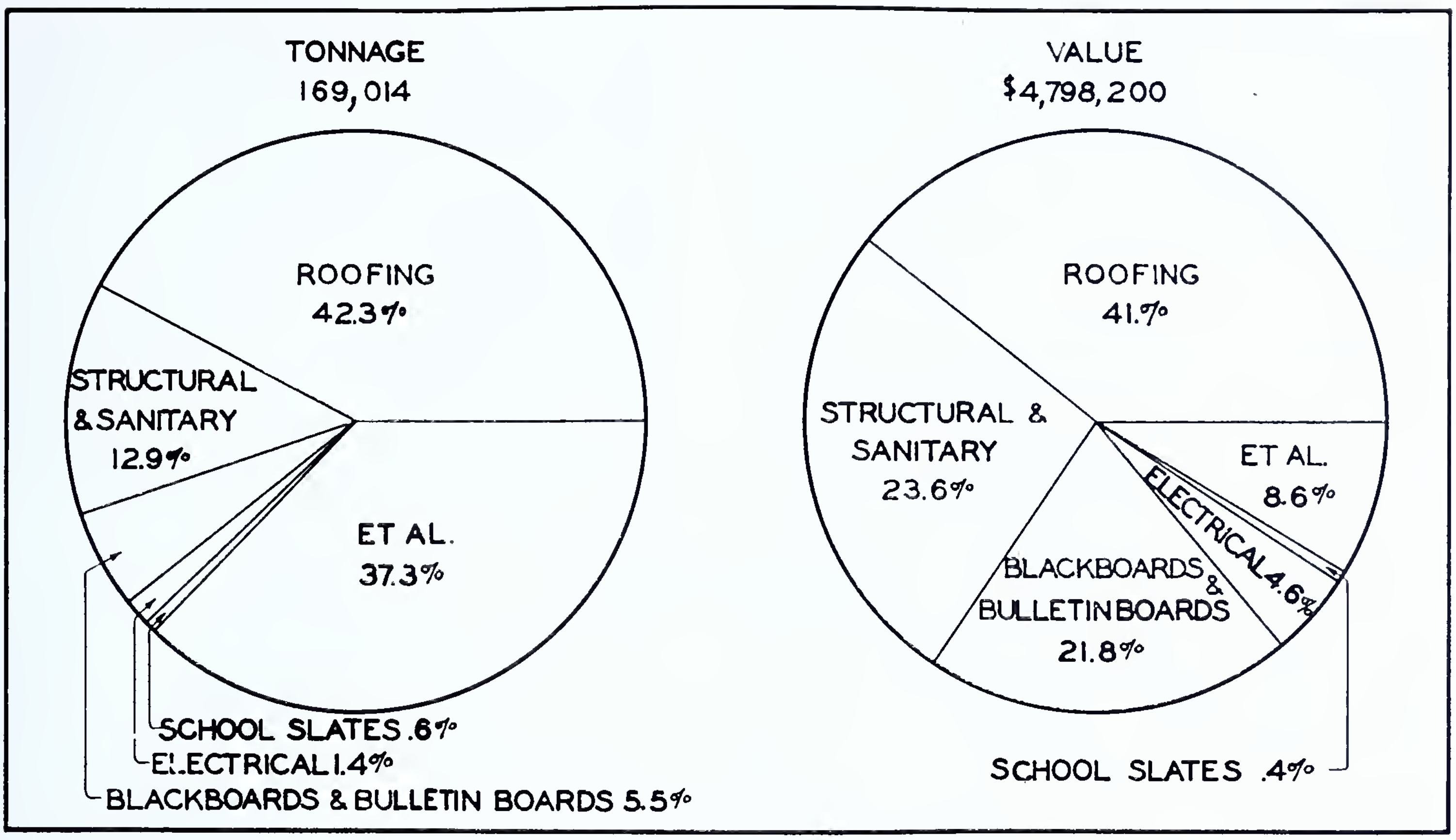

Fig. 71. Uses made of slate sold by producers in Pennsylvania in 1929. (Data from Mineral Resources of the United States.)

of artificially colored slate granules to provide material for the highly colored roofs demanded by many architects and home builders. The most important consideration, whether slate is to be used directly for roofing or indirectly as roofing granules and whether it is naturally or artificially colored, is that the color be fast and one which will not fade leaving a dull and streaked roof.[18]

Slate in a pulverized form known as slate flour is used as a filler in paints, road asphalt-surface mixtures, roofing mastic, and various other products. All of the slate produced in the Peach Bottom district of Pennsylvania is granulated and powdered, while only a small part of the slate produced in Northampton County is marketed in this form. All of the roofing and so-called mill stock slate is produced in Lehigh and Northampton counties.

Value.

Slate is the most valuable common rock product produced in Pennsylvania, its value amounting to about $23.30 per ton in 1931. In fact, its high value per ton and rather limited occurrence on the earth's surface almost exclude it from the group of common rock products. However, because slate's principal use is for building (roofing) it seems more logical to discuss it with the other building materials than to leave it for separate discussion in a later chapter.

There is considerable variation in the value of slate, depending upon the use for which it is adapted. Slate that can be used for blackboards and bulletin boards has the highest value (about $100 per ton in 1931) followed by electrical slate (about $85 per ton), structural and sanitary slate (about $45), and slate for billiard-table tops (about $50). Slate sold crushed in the form of granules and slate flour is at the lower end of the scale with a value of only $6 per ton.

Markets.

It is a striking fact that 62 per cent of the slate sold in 1929 (as reported by the United States Bureau of Mines) was marketed in the northeastern part of the United States—in Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania and West Virginia. Five of the States of this group produced 92 per cent of the country's slate and all of the others are located close to the slate producers. It seems, therefore, that nearness to the sources of slate explains the concentration of over half the slate consumption in the relatively small group of States mentioned.

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[18] Much of the so-called fading and discoloring of slate roofs, especially in cities, is caused not by inferiority of material used, but by deposition on the roofs of industrial dusts and soots. Many colored roofs, whether of slate or of other materials, are blackened and discolored in this way.

From Bureau of Mines data it can be estimated that approximately 82 per cent[19] of the roofing slate distributed in the United States in 1929 was consumed in the group of States discussed in the preceding paragraph. The same group used approximately 66 per cent of the structural and sanitary slate, 86 per cent of the slate used for floors and walks, 85 per cent of the slate used for vaults and covers, 47 per cent of the blackboard and bulletin board slate, 43 per cent of the billiard table slate, 77 per cent of the electrical slate, 36 per cent of the slate used for roofing granules, and 75 per cent of the slate flour. Thus it can be seen that for most purposes northeastern United States uses more than its share of slate. This is particularly true of roofing slate, slate used for floors and walks, and slate for vaults and covers; and it is true to a lesser extent of slate

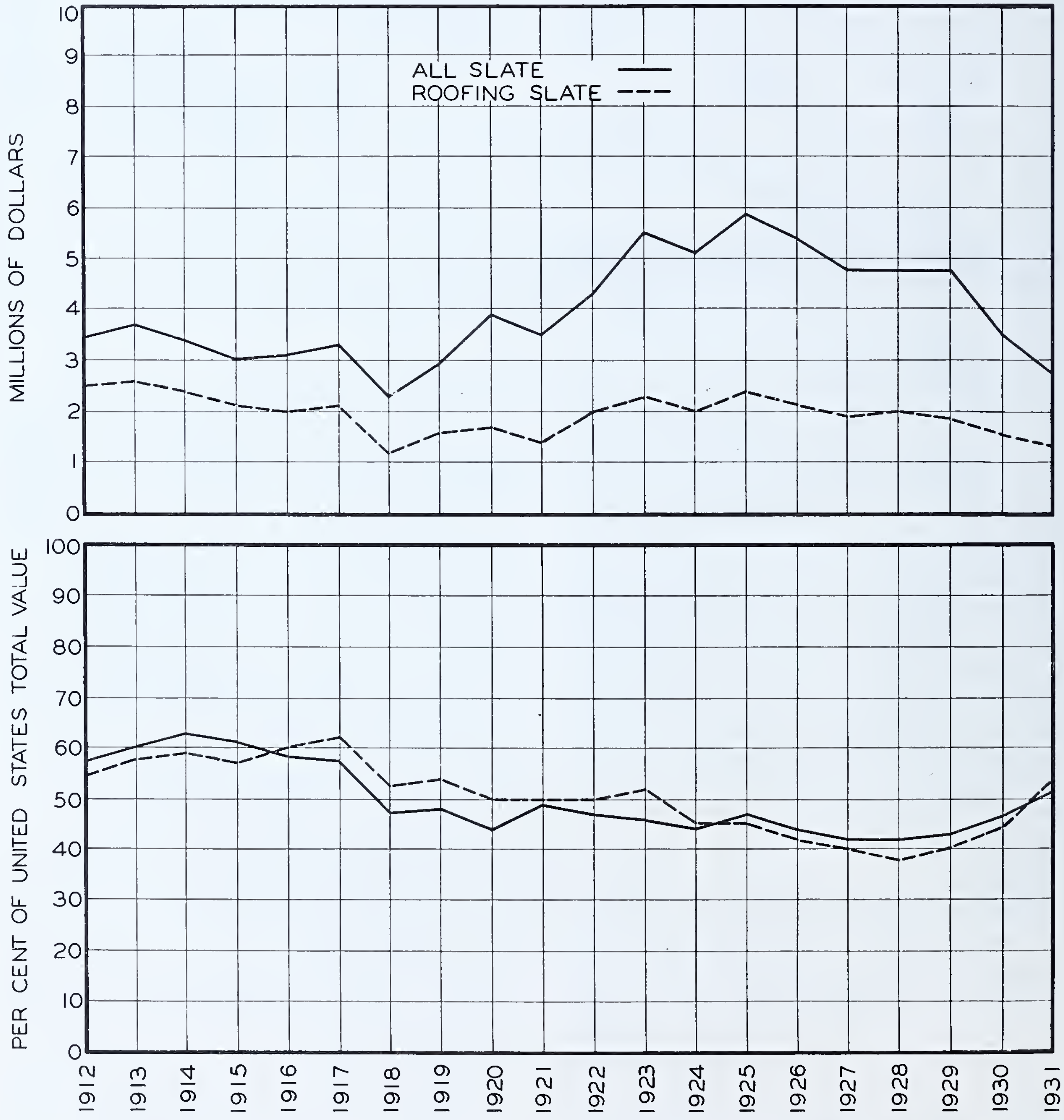

Fig. 72. Recent trends in value of all slate and of roofing slate sold by producers in Pennsylvania and in the State's proportion of the United States total. (Data from Mineral Resources of the United States.)

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[19] All of the percentages given in this and the following sentence are calculated on the basis of square feet except those for granules and slate flour, which are on a weight basis.

for structural and sanitary purposes, electrical slate, and slate flour.

The concentration of consumption of slate in northeastern United States is undoubtedly due to the fact that slate is heavy and must pay comparatively high freight rates. Consequently, it can best compete with other roofing and structural products near the place where it is quarried. A striking predominance of slate roofs in and near the slate districts of Pennsylvania gives testimony as to the effect of propinquity. On the other hand, slate has no good competitors in the blackboard field or as a material for billiard-table tops, and consequently these markets are more scattered over the whole United States. The low percentage of roofing granules used in northeastern United States is probably due to the fact that they cannot compete with slate roofing near the points of slate production. Instead, they find their best markets farther west in Illinois, Indiana, Michigan, and Ohio.

It is difficult to maintain adequate outlets for the slate which is produced or could be produced. Many other commodities compete with slate, particularly for roofing. Various types of roofing are much more widely advertised than slate, and many of them are synthetic products that can be manufactured at a low cost. Similarly, slate meets with numerous competitive materials in structural and electrical applications. It has no serious competitors for the blackboard market, but this market is, unfortunately, not a very large one.

For about ten years after the World War there was great activity in schoolhouse construction to catch up with building programs retarded by the War, but that period of activity is now past, and such construction has returned to normal. The decline in demand for blackboard slate (of which Pennsylvania is the only producer in the United States) and the effect of increasingly strong competition in other fields are reflected in the curve showing the value of Pennsylvania's production within recent years (Figure 72). After rising to a peak in 1925 the total value of the State's production has shown a fairly steady decline since that time.

Color as a Factor in Marketing.—The slates of Pennsylvania are blue-gray while those of the Vermont-New York district are green, red, purplish, and other colors. These highly colored slates command a higher price for roofing and certain other purposes than blue-gray slates; and certain variegated slates and slates having freak colors, both types produced in the Vermont-New York district, command even higher prices. This advantage of the Vermont-New York district is reflected in a high proportion of roofing slate in its sales—53 per cent in contrast to about 45 per cent for Pennsylvania. It is quite possible that experimentation may result in the development of a method whereby the State's roofing slate may be permanently colored red, green, or some other shade. Such a process would undoubtedly open up new markets.

Recent Trends in Production and Value.

From a marked "low" in 1918 the value curves of "total slate produced in Pennsylvania" and "roofing slate produced in Pennsylvania" rose irregularly to high points in 1923 and 1925 (Figure 72). Since then there has been an average downward trend in response to increased competition and to depressed market conditions. The value curve of the State's roofing slate production has been steadier than the curve for total slate, probably because the latter includes blackboard slate which was temporarily much in demand during the post-War school house building program.

Pennsylvania's proportion of the total value of slate produced in the United States showed a very gentle net decline from 1914 until 1928, interrupted by temporary increases. During 1929, 1930, and 1931 there was a steady increase. Pennsylvania's proportion of the total value of roofing slate produced in the United States showed a somewhat more marked downward trend than that of total slate between the years 1917 and 1928. Apparently Pennsylvania's roofing slate was being displaced more rapidly than some of the other grades of slate during that period. Pennsylvania's proportion of the United States total of roofing slate increased in 1929, 1930, and 1931 just as did its proportion of the total value of all slate.

Freight Rates.

Slate producers have had difficulty in obtaining freight rates as low as those of competitive materials. Now marketing in several districts has been assisted in some degree by improved freight-rate classifications. Such adjustments are very important to the industry since they widen its market area. Owing to recent reductions in rail-water rates, increasing quantities of slate are reaching Pacific Coast points.

Imports and Exports.

Over 85 per cent of the slate exports (by value) of the United States went to Canada in 1931, largely in the form of roofing slate and blackboard material, while most of the remainder went to the United Kingdom.

Nearly one-fifth as much slate is imported into the United States as is exported, the imports coming largely from Italy, Portugal, the Netherlands, and France. Slate carries a high tariff at present. Prior to 1913 the duty was 20 per cent ad valorem, but in October, 1913, it was reduced to 10 per cent. In September, 1922, it was raised to 15 per cent and in 1930 to 25 per cent.

Problems.

For many years the slate industry has lacked efficient selling and advertising agencies. There is, however, evidence of a movement toward bettering this condition through the establishment of joint marketing agencies in some localities to bring about better contacts between producers, distributors, and roofing and setting contractors, thus promoting sales and insuring better service to ultimate consumers. The big problem in the slate region is to find a market of sufficient extent to absorb the normal output of the quarries. Marketing would be assisted by improved freight-rate classifications.

A considerable amount of work has been carried on under the direction of the Federal Specifications Board toward the end of developing specifications for roofing slate for government use. It is thought that such work will eventually enable slate producers to classify their product more carefully and to direct each type to the use for which it is best suited. Also, it will make it possible for consumers to obtain dependable slate with a minimum of inconvenience.

Waste in slate quarrying is still a big problem, which, however, the developing of a market for irregular slabs for landscaping is helping to solve. A considerable amount of grinding and polishing sand is used in preparing slate for market. It has been customary to discard the sand once used, but some companies are effecting a saving through recovering for further use sand which has been used once but not worn out.

Several processes have been developed by which slate is made more ornamental than it normally is and hence has new markets opened to it. One of these processes, marbleizing, consists of artificially coloring slate to make it look like marble, onyx, or other decorative stones, or clear-grained woods. This is done by adding color in oil and heating the piece of slate in a kiln, then varnishing, and polishing with pumice. Another product, known as Struco slate, is made by lacquering one or both sides of a piece of slate in various colors, with or without pattern. The lacquer is applied with compressed air and is air-dried.

"Miscellaneous Stone"

Under the heading of "miscellaneous stone" the United States Bureua of Mines includes a variety of rock materials which have uses similar to those of the common rocks just discussed, but which are not important enough to justify separate treatment. For Pennsylvania, "miscellaneous stone" includes mica schist, argillite, and a number of other materials not specified.

"Miscellaneous stone" produced in Pennsylvania had a tonnage of 147,990 in 1930 and a value of $269,003. Seventy-nine and five-tenths per cent of this material was used for concrete and road metal, 6 per cent for building stone, and the remaining 14.5 per cent for various other uses, including railroad ballast.

Minor Common Rock Industries

There are a number of small common rock industries in the State, some of which will be mentioned briefly here.

Serpentine.

Serpentine occurs at several points in southeastern Pennsylvania, but the only serpentine quarry reported as recently in operation is in southern Lancaster County. The chips obtained are used for terazzo floors. No production figures are available.

Talc.

Talc, which frequently occurs with serpentine, is quarried near Easton and is ground to a fine powder for use as filter in paint, for making toilet powder, et cetera. Exact production figures are not available, but the amount must be small since Pennsylvania, New Jersey, and Maryland, together, produced only about 8,000 tons in 1929 with a value of $96,000. The largest producers in 1929 were New York, Vermont, and California. Domestic talc producers are protected by a tariff of 1 cent per pound on crude or roughly finished talc and 35 per cent ad valorem on ground material and manufactures.

Feldspar.

Feldspar is used in china and porcelain, in scouring soap, in emery wheels, in certain kinds of glass and enamel, et cetera. It is a constituent of granite and occurs abundantly in southeastern Pennsylvania, but the commercial occurrences are relatively restricted. Quarrying has been done in Delaware and Chester counties, and thousands of tons of crude and ground spar were produced annually for use in pottery making for a number of years. Pennsylvania produced 2,052 long tons of crude feldspar (United States Bureau of Mines data) valued at $8,851 in 1928, but that is the last year for which separate Pennsylvania figures are available. According to Stone[20], the industry dwindled until in 1931 only one quarry was operating and that intermittently. Its crushed spar was sold for poultry grit.

Mineral Paints and Mortar Colors.

Common rock materials high in iron are used in the manufacture of mineral paints and mortar colors.

"Pennsylvania has long led in the production of mineral paints, using the oxides and carbonates of iron—ochers, umbers, siennas, and colored shales. Ocher—red, yellow or brown—comes from the brown iron ores of the limestone valleys. Umber contains in addition to the iron a little manganese. Umber has been mined near Bethlehem, Doylestown, and west of Bethel, Berks County. A pulverulent, high-iron ore yielding sienna has been mined near Reading.

"A bed of iron carbonate 2 to 4 feet thick. . . . has been mined since 1856 in southern Carbon County.

"Black, yellow, and red shales from many horizons and many places have been worked in Pennsylvania for paint. Red iron ores have been mined in Union, Perry, Tioga, and Berks counties, and brown iron ore in Carbon County. Among minor substances entering into paint-making in Pennsylvania are graphite, soapstone and talc pyrite and chromite, clay and kaolin.

"Production figures are not available for recent years. In 1914 production was 9,862 tons valued at $121,888. Of this 3,799 tons valued at $34,223 was ocher.

"Mortar colors, used for tinting mortar, cement and concrete, are obtained from the same materials as those from which paint is made. They are usually mixed with other materials and may even contain coal from the anthracite culm heaps. In 1912 the production [of Pennsylvania] was 2,550 tons valued at $24,857. Figures for later years are not available."[21]

Pennsylvania as a Source of Building Stone

The growing popularity of stone houses and stone buildings of all sorts has led, within recent years, to an increased interest in our building stone situation.

Present Production

Figures 56 and 57 display graphically Pennsylvania's present production of stone for various purposes including building stone. Attention is called, also, to Table IX, page 105. On a tonnage basis granite is the most important building stone which the State now produces, and it is followed by slate and limestone. Trap, sandstone, and miscellaneous stone are of relatively minor importance. On the basis of value, slate constitutes three-fourths of the total, being followed by granite, sandstone, limestone, trap, and miscellaneous stone in the order named.

Pennsylvania's Place as a Producer of Building Stone.

Pennsylvania does not lead in the production of any of the building stones except roofing slate. This is essentially a building stone, so it has been included as such in Figures 56 and 57. Although formerly exceeded by Vermont in the production of roofing slate, Pennsylvania occupied first place in 1931, with 53 per cent of the country's total value. There is some question, however, whether roofing slate should be considered with the other building stones as it is not exactly competitive with them.

Building stone other than slate produced in Pennsylvania in 1929 according to the United States Bureau of Mines had a tonnage of approximately 211,450 and a value of $594,372, but these figures are undoubtedly too small. It is probable that a considerable amount of building stone for local use is quarried when needed from openings which are not regularly operated quarries. Moreover, a good deal of loose rock is available at the surface in many parts of the State, and a considerable amount of building material must be obtained from this source. If figures covering such use were available, the reported totals of building stone produced would probably be considerably increased.

It is apparent from Figure 73 that Pennsylvania's small production of building stone (1½ per cent by value of the United States total) consists almost entirely of stone for rough construction, and it may be added that some kind of stone suitable for rough construction can be obtained in every county of the State. Rough architectural stone and dressed stone together made up but 7.1 per cent of the State's total in 1929 according to the Bureau of Mines' figures for that year (See Table IX, page 105).

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[20] Stone, Ralph W., op. cit., p. 34.

[21] Ashley, George H., A Syllabus of Pennsylvania Geology and Mineral Resources, Pennsylvania Geological Survey, Fourth Series, Bulletin G-1, 1931, pp. 134-135.

Of the regular building stones (excluding slate) produced in the United States (as reported by the United States Bureau of Mines), limestone made up 47 per cent of the total by value in 1929. Pennsylvania, though it has abundant limestone, produced only four-tenths of one per cent of the value of all the limestone which was used for building stone, while Indiana (home of the famous Bedford Limestone) produced about 90 per cent. Marble made up 27 per cent of the total value of building stones (other than slate roofing) produced in the United States in the same year, but Pennsylvania produced practically no marble for building purposes. In its production of granite, which constituted 18 per cent of the United States total, Pennsylvania ranked ninth with 3 per cent of the total. Sandstone was next in importance, making up 6 per cent of the total value of building stone in the United States (excluding slate roofing), and in its production Pennsylvania ranked third with 7 per cent of the United States total. Although Pennsylvania ranked second in the production of basalt (trap rock) for building purposes, with 31 per cent of the country's total value of this stone, the value of basalt and trap produced for building in the United States was only about one-tenth of one per cent of the total value of all building stone. From the foregoing it may be seen that Pennsylvania does not play an important part in the production of building stone other than slate roofing.

It has already been pointed out that the Vermont and New York roofing slate has a color advantage over the Pennsylvania product. Consider, for a moment, what our present information suggests regarding the other building stones. In eastern Pennsylvania most of the limestone and marble are badly crushed by mountain building; elsewhere in the State the limestone is frequently so dark colored as to be undesirable. As a result of this situation many Pennsylvania buildings are made of stone from other States—for instance, limestone from Indiana and granite from Massachusetts — or are constructed of manufactured products such as brick and cement fabricated from Pennsylvania rocks.

The Future of Pennsylvania's Building Stone Industry

Present indications are that Pennsylvania is very well supplied with building stone[22] but not with the better grades of architectural stone. There is the possibility, however, that more intensive field work and laboratory tests than have already been carried on may reveal building stone

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[22] Stone, Ralph W., Building Stones in Pennsylvania, Penn. Geological Survey Bull. M-17, 1932.

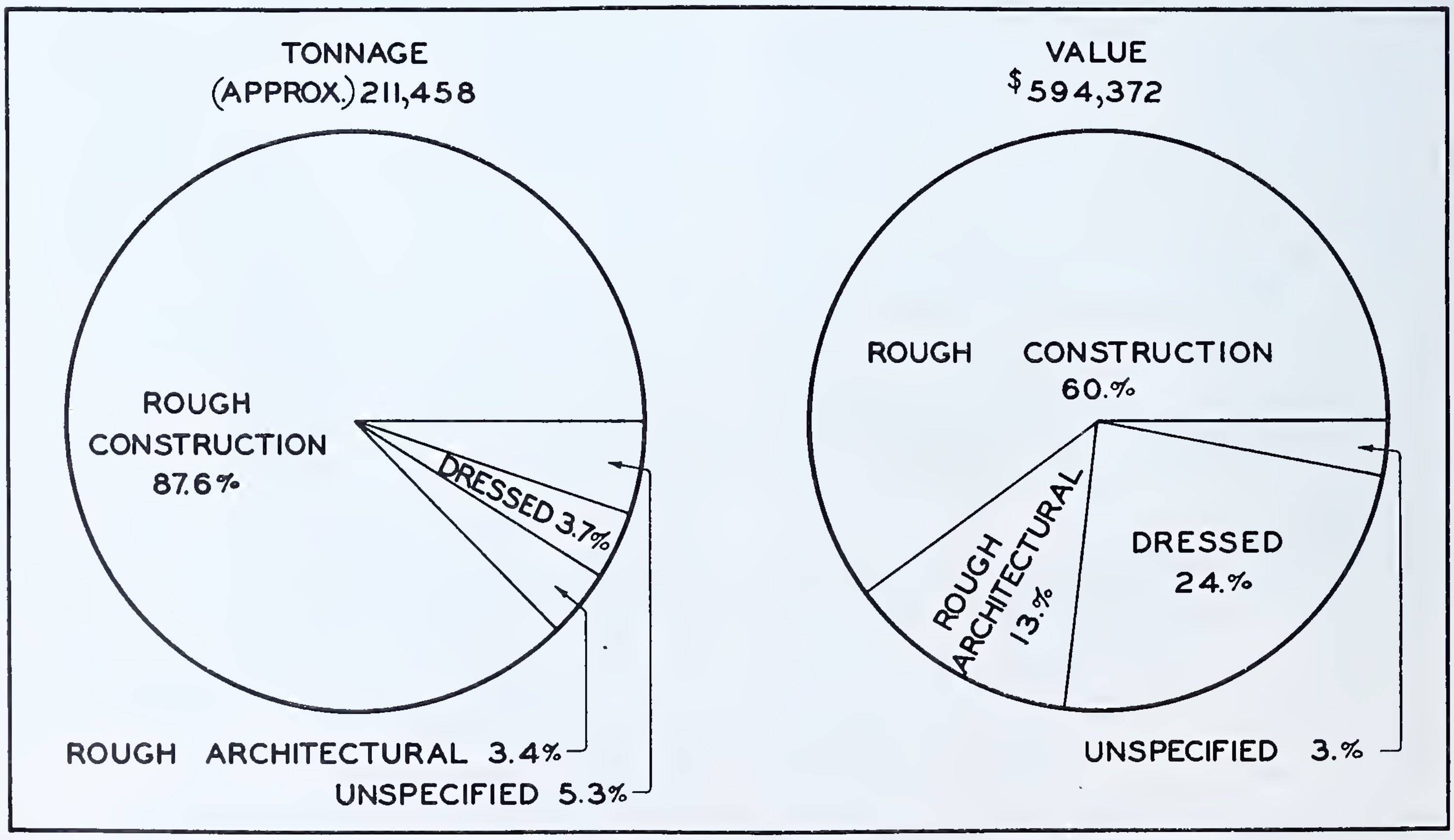

Fig. 73. A use classification of the total building stone (other than slate) sold or used by producers in Pennsylvania in 1929. (Data from Mineral Resources of the United States. See footnote on page 105 regarding dressed granite.)

sufficiently solid, with a desirable enough color, and at a low enough cost to compete successfully with some of that now brought from other States. Certainly the State is well located from a market standpoint, and has a great variety and quantity of stone. Again, a demand may be built up for certain dark-colored limestones or granites not now popular because of their color. The market for central Pennsylvania quartzites may be extended. In these and other ways the use of Pennsylvania's building stones may be considerably increased, but it is not probable that Pennsylvania will ever become a very important factor in the building stone market.

Rock Cutting, Shaping, and Finishing Industries

There is a group of industries in Pennsylvania engaged in cutting, shaping, and finishing marble, granite, slate, and other stone for building, monumental, and miscellaneous uses. About 3,800 persons were engaged in these industries in Pennsylvania in 1929 according to the United States Census. The value added by manufacture amounted to $8,716,571 and the value of products, $12,636,522. The variety of products resulting is shown in Figure 74.

The raw materials of these industries, in so far as they originated in Pennsylvania, have been included in Figures 56 and 57 which show the tonnage and value of unprocessed rock materials produced in Pennsylvania in 1929. A portion of the rock used (for example, the marble) was shipped in from other States. The establishments are distributed widely over the State, but there is a marked concentration near population centers—for instance in Philadelphia County and in and near Pittsburgh in Allegheny County.

Transportation

Transportation is particularly critical for the common rock industries. The products of these industries are low in value in proportion to their bulk, and, therefore, transportation costs prohibit shipment for any considerable distance. With increasing distance from point of production, transportation costs rapidly increase the total cost to consumer to the point where some competitive material is cheaper.

Common rock materials are transported by railroad, by truck, and by water within the State. There are many small quarries, most of these disposing of their product not far from the place of production and delivering by truck. Trucking is, however, too expensive for long hauls. Where large operations are carried on at least part of the

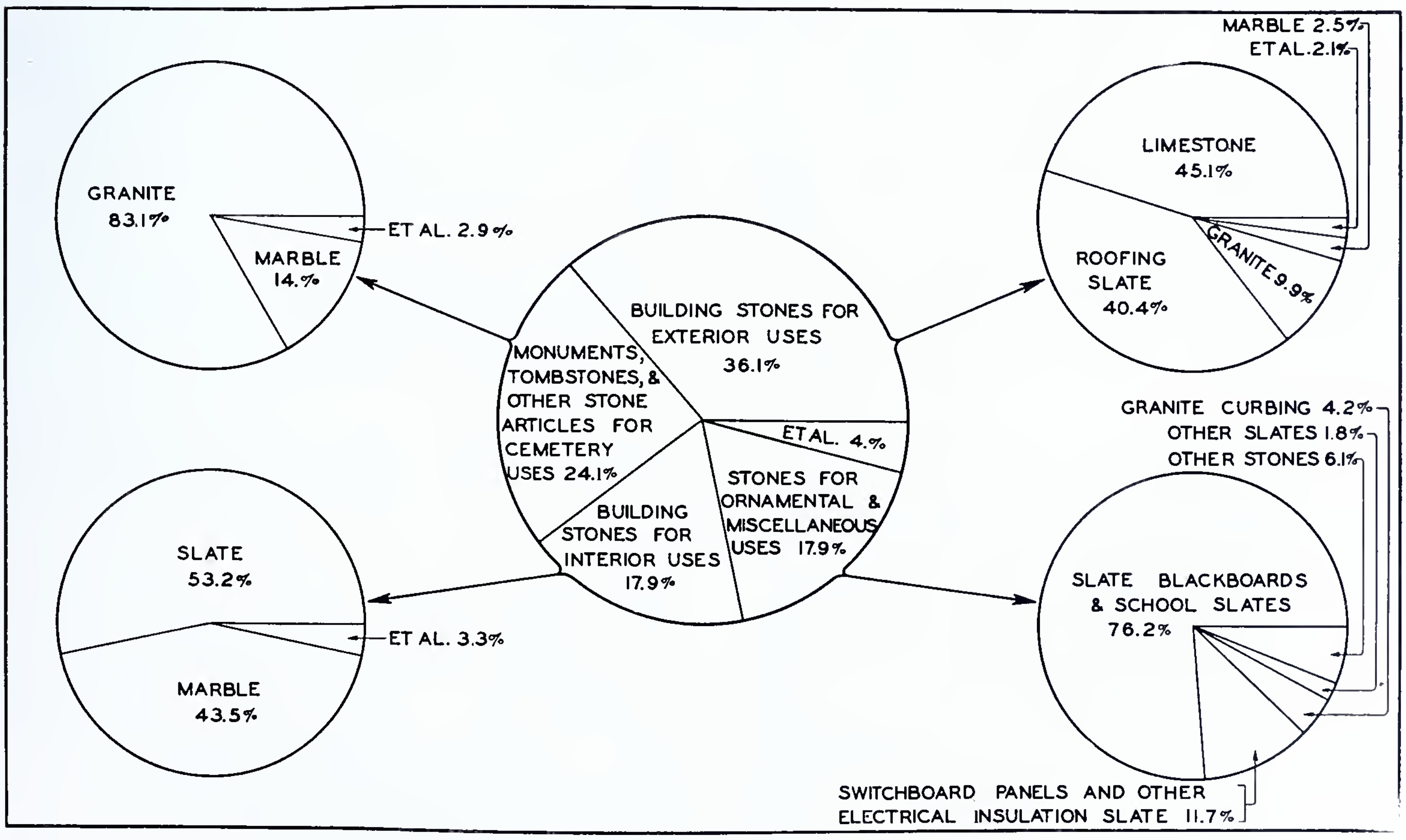

Fig. 74. Products of the rock cutting, shaping, and finishing industries of Pennsylvania. (Data from United States Census.)

product is usually marketed at some distance. Spur tracks serve these larger developments.

With a product as bulky as the common rock materials, water transportation effects a great saving where it can be used. Some use is made of rivers for moving rock products in Pennsylvania, particularly in western Pennsylvania, where it is reported that over 5,000,000 tons of sand and gravel and 32,000 tons of other common rock materials were transported by river barge in 1929.

The cheapness of water transportation is manifested in another way in connection with the State's common rock industries. Because of the cheapness of water haul, foreign rock materials can compete with domestic products in our coastal cities in spite of the long distance the foreign materials move to market. Because of this fact, tariffs have been placed upon slate, granite, clay, and certain other common rock materials in order to protect home industries.

Future of the Common Rock Industries

Pennsylvania still has great quantities of the common rock materials, and there is every reason to believe that most of the common rock industries will be at least as important as they are at present for a long time, and that they will continue to furnish raw materials for important processing industries.

IX

THE CLAY-PRODUCTS INDUSTRIES

Introduction

Pennsylvania is outranked only by Ohio in the total value of her clay products. The State's total for 1929 amounted to about $50,000,000, seventy to seventy-five per cent of this being value added by manufacture. Cost of the raw material, clay, is small as compared with the total value of clay products; it is the processing which gives the ultimate product most of its value.

The two main groups of manufactured products which are based upon clay as a raw material are clay products other than pottery and pottery. Clay products other than pottery have a total value five times as great as that of pottery (Figure 75), and represent a very much larger investment (Table X.)

TABLE X

CAPITAL INVESTED IN THE PRINCIPAL CLAY-PRODUCTS INDUSTRIES OF PENNSYLVANIA[a]

Clay products other than pottery—		
Building brick	$24,285,200	
Paving brick	1,591,500	
Clay refractories (and terra cotta)	44,676,400—	$70,553,100
Pottery and chinaware		5,407,300
Total		$75,960,400

[a] Productive industries report of the Pennsylvania Department of Internal Affairs for 1930.

The manufacture of clay products other than pottery represents a very much larger investment, is more wide-spread, and is of more fundamental importance.

Clay-Products Industries Other Than Pottery

Clay-products industries other than pottery manufacture had a total product value in Pennsylvania in 1929 of about $42,000,000 and a "value added by manufacture" of approximately $30,000,000. Pennsylvania ranked second among the States with 16 per cent of the nation's total value of such products, Ohio being first with 17 per cent. Approximately 13,000 to 14,000 persons were employed by these industries in Pennsylvania.

Clay Refractories

It is not surprising to find that Pennsylvania with its vast fire-clay deposits is the leading producer of refractory products. The total value of such products originating in Pennsylvania in 1929, a little over $16,500,000, was 39 per cent of the United States total.

It was pointed out in the discussion of clay that fire clay has special heat-resistant properties. For this reason most fire clay is used in making refractory materials (heat-resistant products) —bricks, tile, special shapes, and refractory cements—which are used in lining all types of industrial furnaces and kilns. Metallurgical industries, particularly the manufacture of iron and steel, are so important in Pennsylvania that large quantities of refractories are needed. This demand, together with the large quantities of fire clay available and the presence of abundant fuel, has been largely responsible for Pennsylvania's dominance in the manufacture of fire-clay products.

Most of the fire-brick plants are in the bituminous coal field section of Pennsylvania—in Clearfield and adjacent counties near the eastern edge of the field, and farther west in Allegheny and Beaver counties (Figure 76).

Markets for refractories are closely related to the iron and steel industry. When the latter prospers and extends operations the demand for refractories increases. A future movement of the iron and steel industry to the Atlantic seaboard has been predicted (see chapter on iron and steel), which would mean, of course, a shift of the principal refractories markets to these eastern localities.

Brick (other than Fire Brick)

Next to refractories the most important clay products manufactured in Pennsylvania are face brick and common brick. The face brick manufactured in Pennsylvania in 1929 had a total value of $8,013,460; the common brick, $5,584,118; the two together totalling $13,597,578, almost as much as the value of fire-clay products. Pennsylvania ranked first among the States in the production of face brick and second in the production of common brick with Ohio first.

Common bricks are used for structural purposes where the brick is not required to possess

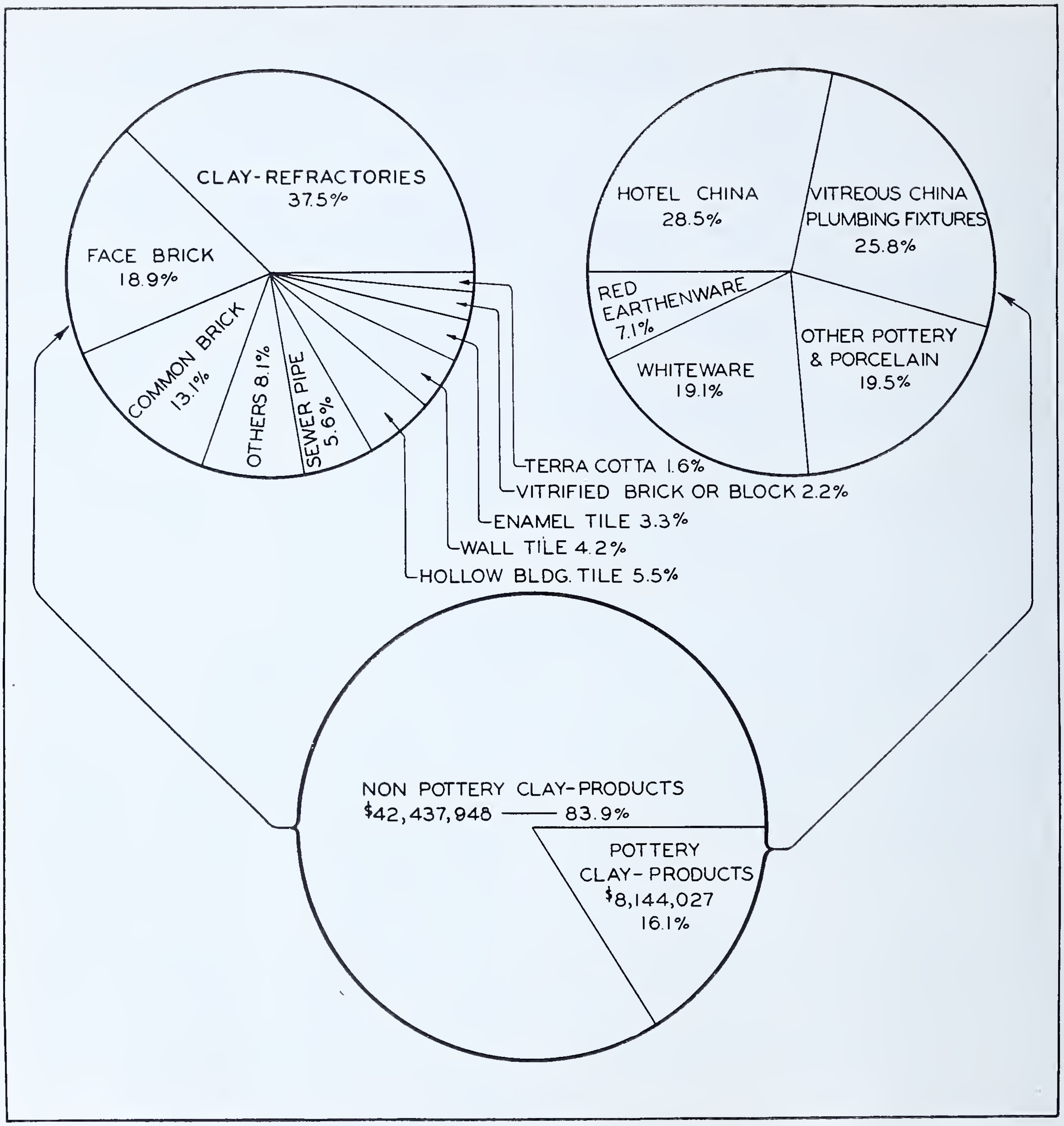

Fig. 75. Clay products manufactured in Pennsylvania in 1929. (Data from United States Census with a few minor estimates by the author.)

excellence as to color, strength, or uniformity of shape and finish, and are made from low-grade clays or shales. Since such materials are available almost everywhere, common-brick plants are numerous. Their product has too small a value in proportion to its bulk to be shipped any considerable distance.

Face brick has a better finish and is a higher-grade product than common brick. Shales and low-grade fire clays are the raw materials commonly used, and, as a result, the industry is concentrated largely in the western half of the State where such materials are available. Face brick from this part of Pennsylvania is said to move in considerable quantities to New England and the Atlantic seaboard.

Cost Items.

In the manufacture of brick two costs stand out as the most burdensome—labor and fuel. The labor turnover is large in the smaller plants, and the resulting lack of experience and interest

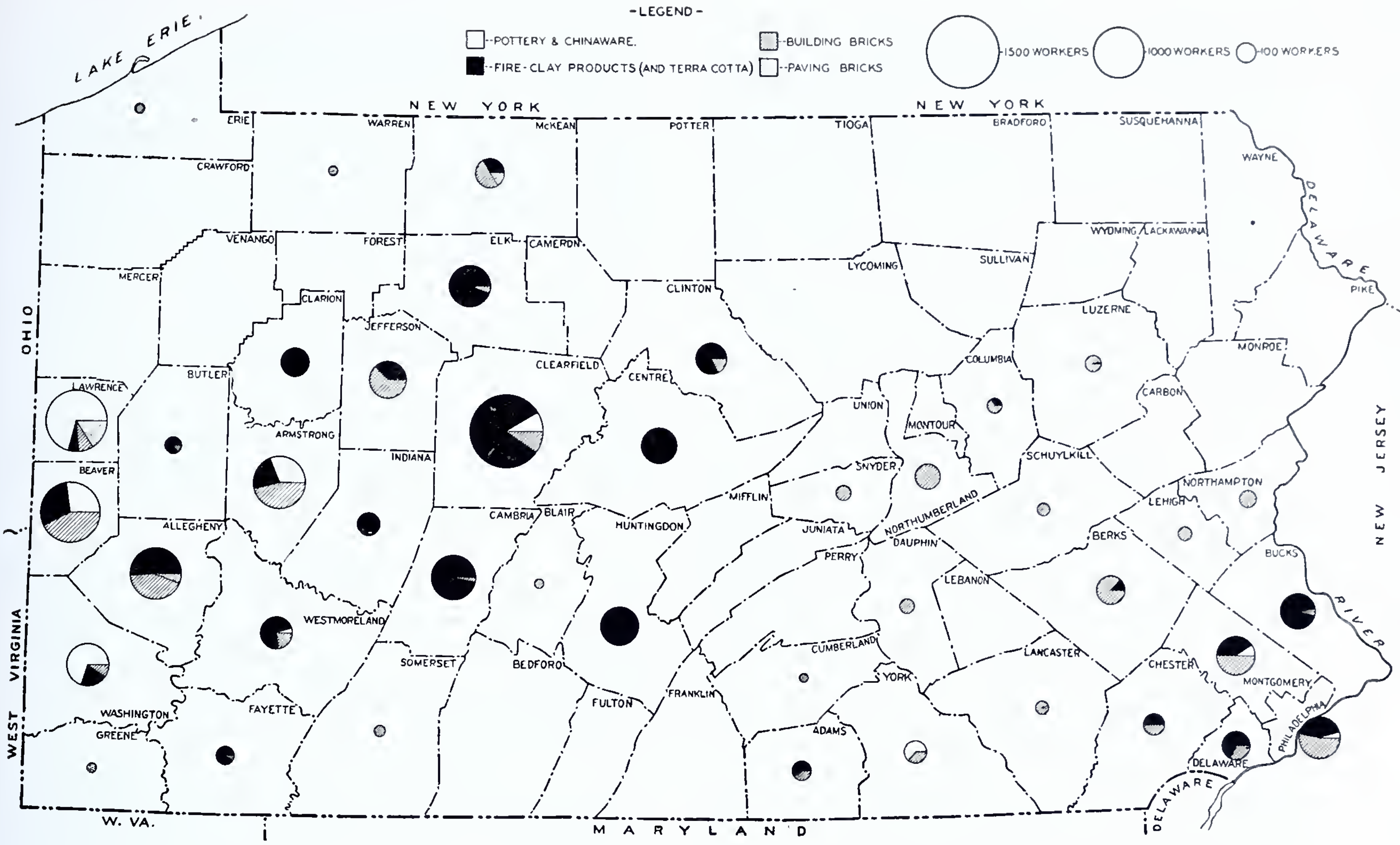

Fig. 76. Map of Pennsylvania showing distribution of clay-products industries. Areas of circles proportional to number of workers. (Based on data in Seventh Industrial Directory of Pennsylvania Department of Internal Affairs.)

means a high labor cost per thousand brick. Partly because of this inefficiency of small plants the number of establishments has been decreasing while average plant capacity has been increasing.

The second major cost item is fuel for firing. Since the firing takes from six days to two weeks, the availability, price, and economic use of fuel are important determinants of the success or failure of an enterprise. Cost is, in general, the determining factor in deciding the fuel to be used. Thus, the availability of bituminous coal in the western half of Pennsylvania as well as the availability of good clays has been important in promoting the face-brick industry there.

Markets.

For common brick, and, to a somewhat lesser extent, for face brick, raw material is readily available in so many places that its presence has been considered less important in locating plants than the presence of a market. There is a marked concentration of plants in Pennsylvania in the general vicinity of Pittsburgh, and a second area of concentration in the vicinity of Philadelphia (Figure 76). The presence of fire clay and other clays, fuel, and market—all have helped determine the location of the western Pennsylvania brick industry. Good clays are available in the southeast, too, though not fire clay, but fuel is relatively expensive. More than any other factor it has been the presence of Philadelphia, a large city and hence a great market for brick, which has caused a concentration of brick manufacturing in southeastern Pennsylvania.

" . . . . . This city claims to have had the first brick house in America built in 1633 by William Penn as a gift to his daughter. The house still stands as a historical curiosity in Fairmount Park. The bricks of which it was constructed, however, were imported from Holland. As much of the soil upon which Philadelphia rests is clay, the city itself contains a great many brickyards. Its needs are also supplied by other yards on its outskirts. Philadelphia advertsies itself as the 'City of Homes.' The houses that constitute these homes are 2½-story dwellings, built in rows and made of brick. Houses of this type all nearly alike cover acres and acres of ground in West Philadelphia and North Philadelphia."[1]

Competition from Concrete.

The field so long dominated by brick has been, within recent years, invaded by concrete. There was a temporary decline in the face of this competition, but, after that, the brick-makers rose to the occasion by more widespread advertising of their wares and by educating the people as to the usefulness of their commodity. Latterly, the advance in the use of concrete has been a direct stimulus instead of a check to brick manufacturers, because bricks have been used in connection with concrete to lend it variety and beauty.

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[1] Keir, Malcolm, Industries of America—Manufacturing, 1928, pp. 521-522.

Other Products

Besides fire-clay products and brick (and, of course, pottery), sewer pipe, hollow building tile, wall tile, enameled tile, vitrified brick or block, terra cotta, and a number of less important products are manufactured from clay in Pennsylvania. The lower-grade, bulkier products (these, with brick, are often referred to as the "heavy clay products") are made here and there from local clays to satisfy what is largely a local demand. Some of the more valuable products, on the other hand, require special clays and are marketed at considerable distances from their points of production.

Recent Trends in Production and Value

Although the present chapter does not include nonclay refractories, they have been included in Figure 77. This inclusion was necessary because of the impossibility of accurately separating nonclay refractories from clay products for the various Census years. It is probable that the trends shown are approximately true of clay products exclusively of nonclay refractories.

There has been a general upward trend in "value added by manufacture" interrupted by temporary declines as in 1921 and 1927.[2] During the same period, 1914 to 1929, the State's proportion of the United States total showed a net increase of about 4 per cent.

Pottery

The total value of pottery manufactured in Pennsylvania in 1929 was $8,144,027. Of this $6,258,792 was value added by manufacture. Pennsylvania ranked third among the states with

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[2] In the curves showing Pennsylvania's proportion of the United States total, data for establishments with products under $5,000 in value were included for 1919 and prior years but not for 1921 and subsequent years. The discrepancy thus introduced is very small.

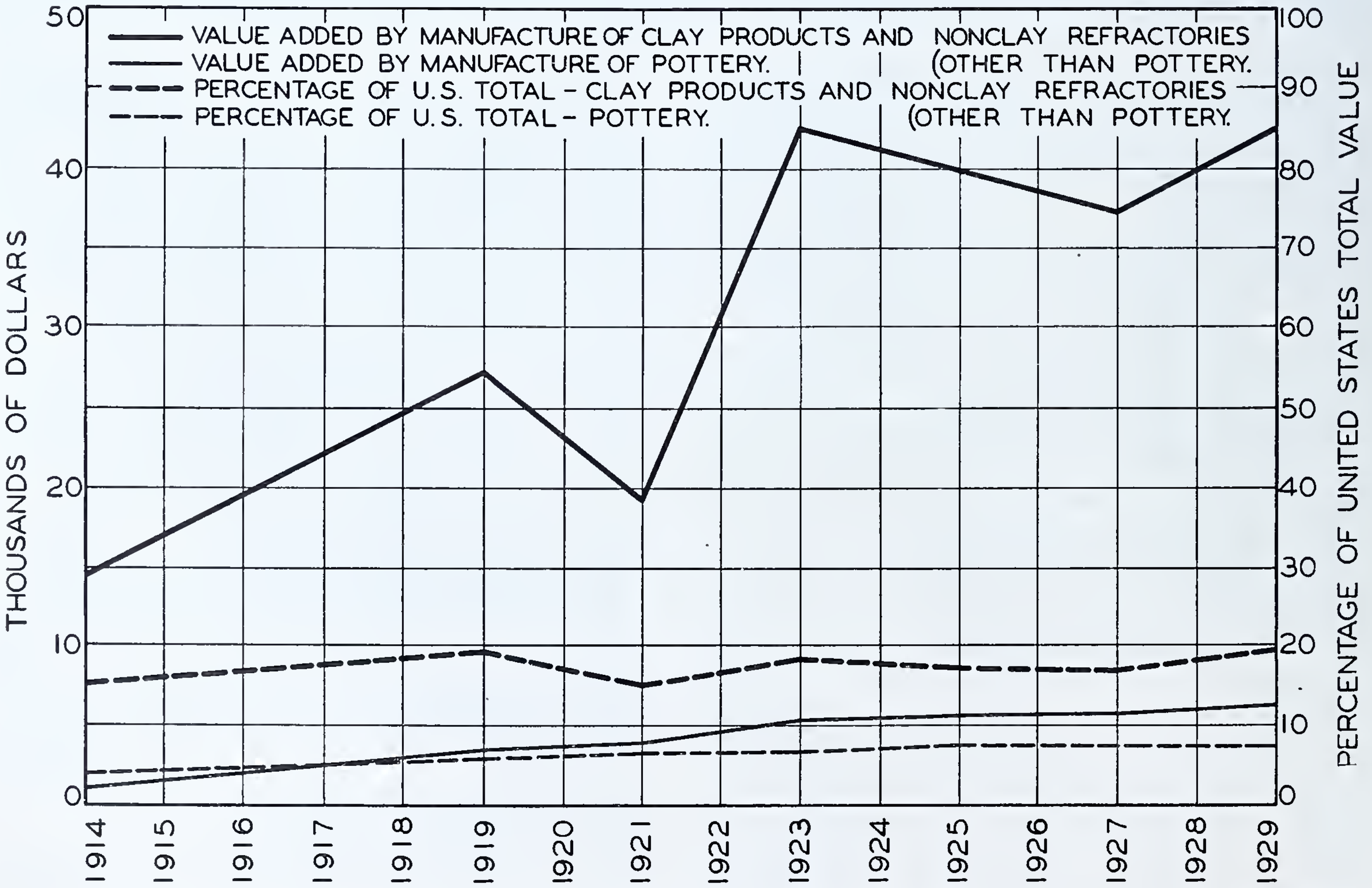

Fig. 77. Recent trends in the value added by manufacture of clay products and nonclay refractories and State's proportion of the United States total. (Data from United States Census.)

7.6 per cent of the United States total, Ohio and New Jersey ranking first and second respectively. Three thousand three hundred and four persons were employed by the industry in the State.

Hotel china, vitreous-china plumbing fixtures, whiteware, and red earthenware stand out as the principal pottery products made in the State, but a number of minor products might be listed (Figure 75).

Location of the Industry

Although some pottery is made in the vicinity of Philadelphia in southern Pennsylvania, the principal pottery manufacturing is carried on in Beaver and adjacent counties in the western part of the State (Figure 76). This western Pennsylvania pottery-producing region is an extension of the industry of Columbiana County, Ohio, which borders Beaver County on the west, East Liverpool, Ohio, being the principal pottery center. Cheapness of high-grade coal and a supply of skilled labor have been important factors in initiating and maintaining the pottery development of this locality. Clay is brought in from the Southern States and even from Europe. For products requiring imported clay, however, such as sanitary ware, the Trenton, New Jersey, pottery district has a decided advantage.

Trend Toward Modernization

Pottery manufacture in the United States has, in general, been inefficient and slow to adopt improvements. The making of pottery was originally based on a high degree of individual skill, and as a result the workers became powerfully organized. Modernization of equipment or improvement of methods met with strong opposition from labor. Only the cheapness of the fuel and the efficiency of the labor made competition with foreign potteries possible. Modern methods have, however, been invading the pottery industry. The manufacture of sanitary pottery and of electrical fixtures are now carried on as a modern, large-scale manufacturing enterprise, and such methods are threatening to invade other branches of the pottery industry. The industry seems to be entering upon a new era in which the potteries will be operated as large-scale capitalisite enterprises with semi-skilled or trained labor.

Recent Trends in Production and Value

During the 1914 to 1929 period represented in Figure 77 there was a slow but uninterrupted increase in the "value added by manufacture" of pottery produced in Pennsylvania, and a similar slow but steady rise in Pennsylvania's proportion of the United States total. In 1929 the "value added by manufacture" for Pennsylvania's pottery industry was 7.6 per cent of the United States total as compared with 4.2 per cent in 1914.

Future of the Clay-Products Industries In Pennsylvania

Pennsylvania has abundant supplies of most of the lower grades of clay. Much of the best pottery clay used in the State has long been brought in from other States or even from abroad, and although enormous quantities of fire clay occur associated with the coal beds of Pennsylvania "the actual quantity of high-grade fire clays in the State appears to be quite limited".[3] Such deficiencies as the ones mentioned will doubtless curtail the production of some of the higher-grade clay products to some degree and will stimulate the search for better raw materials. In view of the large quantity of clay which is available, however, much of it of good grade, the large supply of fuel, and the State's good situation with respect to markets, an indefinite continuation of Pennsylvania's clay-products industries on a scale at least as large as that of the present seems probable.

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[3] Shaw, J. B., Fire Clays of Pennsylvania, Pennsylvania Geological Survey, Fourth Series, Bulletin M-10, 1928, p. 7.

X
NONCLAY REFRACTORIES

Introduction

As pointed out in the previous chapter, refractories are essentially products which are capable of resisting high temperatures. They may conveniently be divided into the following:

Fire-clay refractories
Silica refractories
Magnesite refractories
Chrome refractories
High-temperature cements

Fire-clay refractories, which are the most important group listed, have already been discussed under "clay-products industries". Some high-temperature cements are classified as clay products and some as nonclay refractories. The other products in the list are commonly considered as nonclay refractories.

Silica Brick

The most important of Pennsylvania's nonclay refractories in terms of value is silica brick. The United States Census reported 14 establishments manufacturing silica brick in Pennsylvania in 1929, with a total production of 213,060,000 bricks valued at $10,452,622, which was 69 per cent of the total value of this product manufactured in the United States. Pennsylvania was thus far in the lead, a fact which is not surprising by reason of the large deposits of raw material and the importance of the metallurgical industries of the State. The industry employed approximately 3,000 men in Pennsylvania in 1928.

"Silica brick has an extensive use in metallurgical industries because of high fusing point and its expansion on heating, but particularly on account of its rigidity and strength at high temperatures. It is used in copper reverberatory furnaces, in copper refining furnaces, in acid converters in the manufacture of steel, in coke ovens, in the roofs of tanks and pot furnaces in glass manufacture, in vertical lime kilns, and in gas retorts. In most types of coke ovens silica brick is used for the canals and ovens. The structure above the floor, except for the facings, is of this

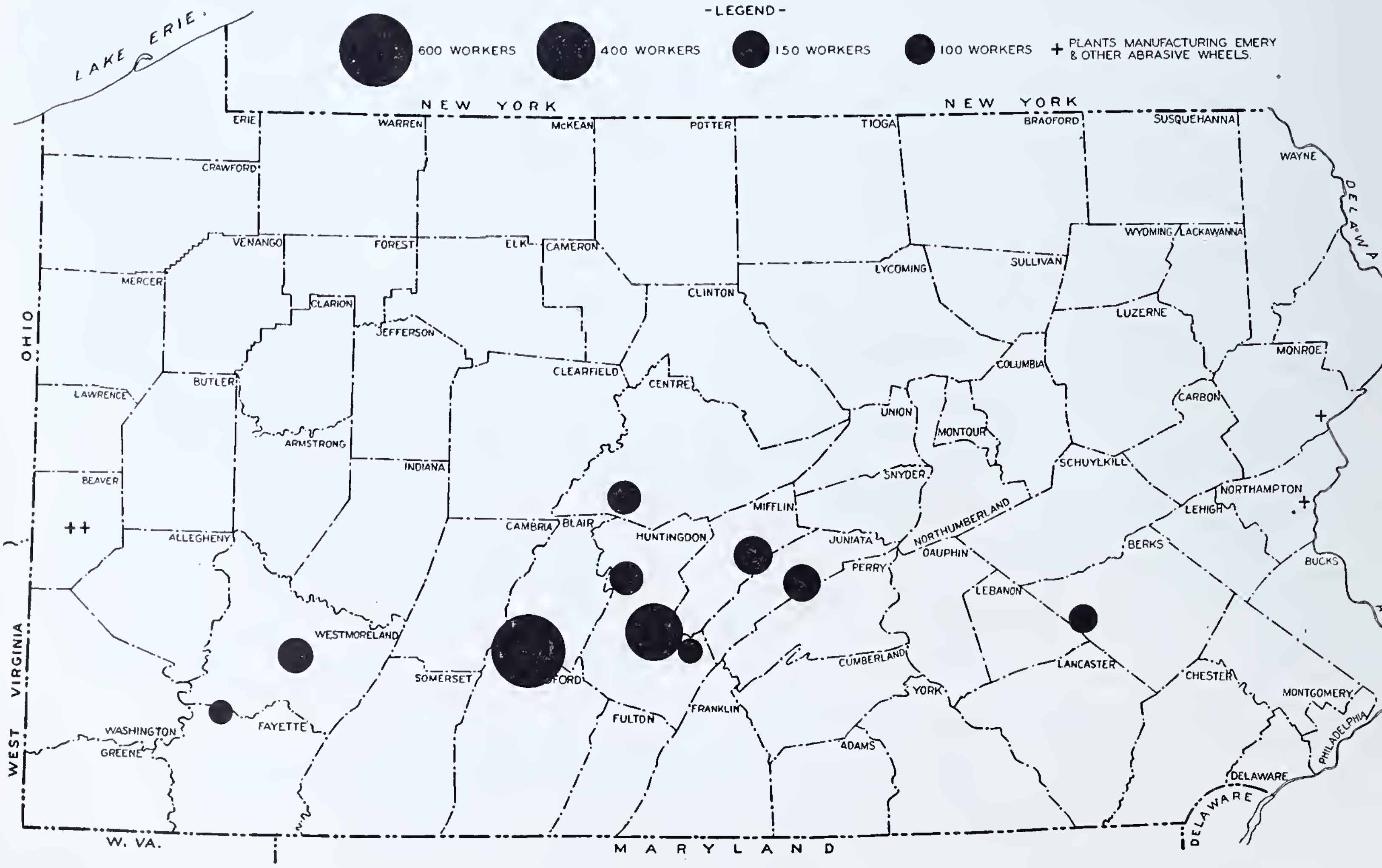

Fig. 78. Silica brick manufacturing plants (black dots) and abrasive products manufacturing plants (plus signs) in Pennsylvania in 1930. (Based on data in Seventh Industrial Directory of Pennsylvania's Department of Internal Affairs.)

brick and in some of the regenerative types of ovens even that below the floor is made of it also. In the steel plants such furnaces as the Martin type have the roofs and floor of silica brick''.[1]

The principal raw material used in silica brick manufacture is ganister (see discussion of ganister in chapter on common rock industries). This material, which must contain approximately 97 per cent silica, is ground, mixed with about 2 per cent of lime, and then the moist mass is molded into bricks and after drying they are fired. The lime serves to hold the quartzite (silica) grains together before firing, and in the firing process it reacts with the silica forming a strong mass. For burning silica brick a good grade of low-sulphur coal is required.

The silica-brick manufacturing industry is concentrated in Huntingdon County and counties adjacent to it on the northeast, north, and west in central Pennsylvania (Figure 78); in Westmoreland and Fayette counties in western Pennsylvania; and in Berks County in the east.

Magnesite and Chrome Refractories

Magnesite and chrome brick are, like silica brick, refractory products. Though all three are used mainly in metallurgy, their uses vary because of differences in chemical character. Magnesite brick is basic, and, therefore, capable of resisting the action of basic slags. Silica brick, on the other hand, is used where resistance to the action of acid slag is necessary. Chrome brick is neutral chemically and is used in positions where either basic or acid slags may be encountered.

Calcined dolomite (calcium magnesium carbonate) in the form of grains is used for repairing open-hearth furnaces. Magnesite brick manufactured in Pennsylvania is made from imported or Washington magnesite. Chromite, which is used in making chrome refractories (and also as a ferro-alloy in making steel), occurs in southeastern Pennsylvania, and has been mined in the past, but none is being mined in the State at present. The United States imports essentially all the chromite used in the manufacture of refractories.

Magnesite and chrome brick are reported together by the United States Census to avoid revealing individual production figures. There were three (Chester, Plymouth Meeting, and Alexandria) magnesite brick manufacturing establishments in Pennsylvania in 1929 and 2 chrome brick plants (Chester and Plymouth Meeting). One magnesite brick and one chrome brick plant, both in Maryland, were the only producers outside of Pennsylvania. From calculations based on the number of plants, it is estimated that the combined magnesite brick and chrome brick production in Pennsylvania in 1929 was approximately 12,000,000 brick with a total value of about $4,000,000.

High-Temperature Cements

In using refractory bricks, tile, et cetera, refractory cements are necessary as mortar. Some of these ''high temperature'' cements consist principally of clay, and for this reason were included in the clay-products industries; others are nonclay, using silica, chromite, or other materials.

High-temperature cements are often made at the same plants which make other refractories. They are important in central Pennsylvania—in Clearfield, Centre, Clinton and some adjacent counties—but are made also in southeastern Pennsylvania, in Allegheny and adjacent counties in western Pennsylvania, and by other scattered plants throughout the State. Shaw[2] states that 13 plants in Pennsylvania reported the production of high-temperature cement in 1928 with a total product value of $2,685,183.

Abrasives and Grinding Wheels

Rottenstone, an earthy siliceous material, is the only natural abrasive originating in Pennsylvania. This material is produced in Lycoming County. Its tonnage and value are small, although no separate data covering this point are available.

There is an abrasive and grinding wheel manufacturing industry in the State, with plants in Philadelphia, Beaver, and Chester counties (Figure 78) and a reported product value in 1928 of nearly $3,000,000. Abrasives and grinding wheels are here, for convenience, grouped with refractories. The industry is based largely upon the use of silicon carbide and electrically-fused aluminum oxide. Although classed here with nonclay refractories, one type of grinding wheel employs some kind of clay for a binder. By varying the fineness of the alumina or carborundum and by varying the character of the binder, grinding wheels of various degrees of hardness are produced. Firing operations are carried out in special kilns although similar to those used for pottery.

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[1] Moore, E. S., and Taylor, T. G., The Silica Refractories of Pennsylvania, Pennsylvania Geological Survey, Fourth Series, Bulletin M-3, 1924, pp. 16-17.

[2] Shaw, Joseph B., The Ceramic Industries of Pennsylvania, The Pennsylvania State College Bulletin, Mineral Industries Experiment Station Bulletin 7, 1930, p. 67.

XI

THE LIME INDUSTRY

Introduction

When finely ground limestone (which is largely calcium carbonate) is heated in kilns (burned) the carbon dioxide is driven off leaving calcium oxide. This material is referred to as "quicklime" or "lime". It has a high affinity for water, and when water is added it "slakes", that is, it combines chemically with the water forming a hydrate of lime, heat being generated in the process. When the slaked lime is exposed to air it sets or becomes hard due to evaporation of the excess water and the reversion of the calcium hydrate to calcium carbonate by absorption of carbon dioxide from the atmosphere.

According to the United States Bureau of Mines, the total value of lime sold by producers in Pennsylvania in 1930 was $4,661,670 and its bulk, 633,520 tons. This was 18½ per cent of the United States total by weight and 18 per cent by value. Pennsylvania ranked second as a lime producer, Ohio being first with 22 per cent of the United States total by weight and the same percentage by value.

The last United States Census indicates that about 68 per cent of the total value of lime produced is value added by manufacture. Thus the lime industry is like the clay-products industries in using an abundant and low-priced raw material, and, hence, having a large "value added by manufacture" relative to total value of products.

According to the Pennsylvania Department of Internal Affairs, the investment represented by the lime industry of Pennsylvania in 1930 was $6,805,900. The same source credits Pennsylvania with 31 lime-producing establishments in 1930 with a total of 1450 employees.

A considerable quantity of limestone reported (in the section on limestone in the Common Rock Industries chapter) as used by iron and steel producers, by alkali plants, by paper manufacturers, and by some other types of establishments is really burned into lime before use. Since such lime burning is just a step in the use of the stone, it is not considered as really belonging with the lime industry and is not included in the figures given above.

Location of Production In Pennsylvania

Lime-producing plants are distributed in Pennsylvania in accordance with the distribution of limestone. Practically all of the plants are confined to the southern two-thirds of the State (Figure 58). In central Pennsylvania they are fairly numerous and tend to occur in northeast-southwest belts corresponding to the trends of the major valleys whose limestone floors furnish the industry's major raw material. Farther southeast, another band of lime plants extends through Lebanon, Harrisburg, Carlisle, and Chambersburg forming a southwestward extension of the Lehigh Valley cement region. Still farther southeast, there are clusters of lime plants in York and Lancaster counties and in Montgomery and Chester counties—in each case making use of local limestone. In western Pennsylvania a few plants are scattered without very definite arrangement through Somerset, Westmoreland, Lawrence, and several adjacent counties, but they are absent north of Butler and Jefferson counties as a result, principally, of a lack of outcropping limestone.

As will be pointed out later, lime for special uses requires special grades of limestone. Thus, although the area of lime production in the State is large, only a few of the plants have the proper limestone available for the manufacture of certain grades of chemical lime.

Lime Plants and Lime Manufacture

Old, small lime kilns are common sights in almost every part of the State where limestone outcrops. Most of these are crumbling with disuse, lime-making now being confined mainly to relatively few large plants which have continuous shafts and rotary kilns, and use only the best limestone. Although most of this concentration took place a number of years ago, the decrease in the number of plants in operation has continued up to the present. The total production has about held its own during the same period, so it is evident that the decrease in number of plants must have been compensated for by increase in individual plant capacity.

Hydrated Lime vs. Quicklime

Lime manufacture is accomplished by heating or "burning" limestone in kilns, which drives off carbon dioxide leaving "quicklime". Lime is always hydrated or slaked just preparatory to use. Recently, mechanical means of hydration have been introduced whereby lime is hydrated, that is, mixed with just enough water so the calcium oxide (quicklime) becomes calcium hydrate. This hydrated lime is a fine white powder which has many advantages in handling and use as compared with quicklime. Hydrated lime may be shipped in paper bags, sacks, or barrels. It will keep indefinitely, is safe to store, and has greater strength than unslaked lime. If unslaked lime (quicklime) becomes wet it may develop sufficient heat to set fire to a building. Moreover, quicklime, if ground, must be shipped in air-tight iron casks. In view of the facts mentioned, it is not surprising to find that hydrated lime is making up an ever increasing percentage of total lime sold. Hydrated lime (including only the product made in hydrating machines and not including hand-slaked lime) amounted to about 37 per cent by weight of the total lime produced and sold by producers in Pennsylvania in 1930. In that year Pennsylvania produced about 18 per cent of the United States total tonnage of hydrated lime; Ohio, 35 per cent.

Raw Material

Limestone is the raw material of the lime industry. This may be a particularly pure high-calcium limestone if the lime is to be sold for certain exacting chemical uses; for many uses, however, very pure limestones are not required. Nevertheless, with the recent concentration of capacity in fewer plants, there has been a tendency to build the larger plants where good quality limestones are available and to abandon those plants which have access only to stone of poor quality.

Fuel

Bituminous coal is the dominant fuel of the lime industry. A few years ago it was reported[1] that of the lime kilns within the State for which information was available nearly 80 per cent used bituminous coal and 20 per cent used coke, while producer gas, oil, and wood were each used by one or more kilns. According to Eckel[2], 600 to 1000 lbs. of medium-rank bituminous coal are used per ton of lime produced.

The Uses of Lime

Lime has a vast number of detailed uses, but they may be grouped under a few headings. Lime for building purposes made up 18 per cent (by weight) of the total sold by Pennsylvania producers in 1930; agricultural uses accounted for 26 per cent of the total; and the remainder, 56 per cent, was used for various chemical purposes (Figure 79).

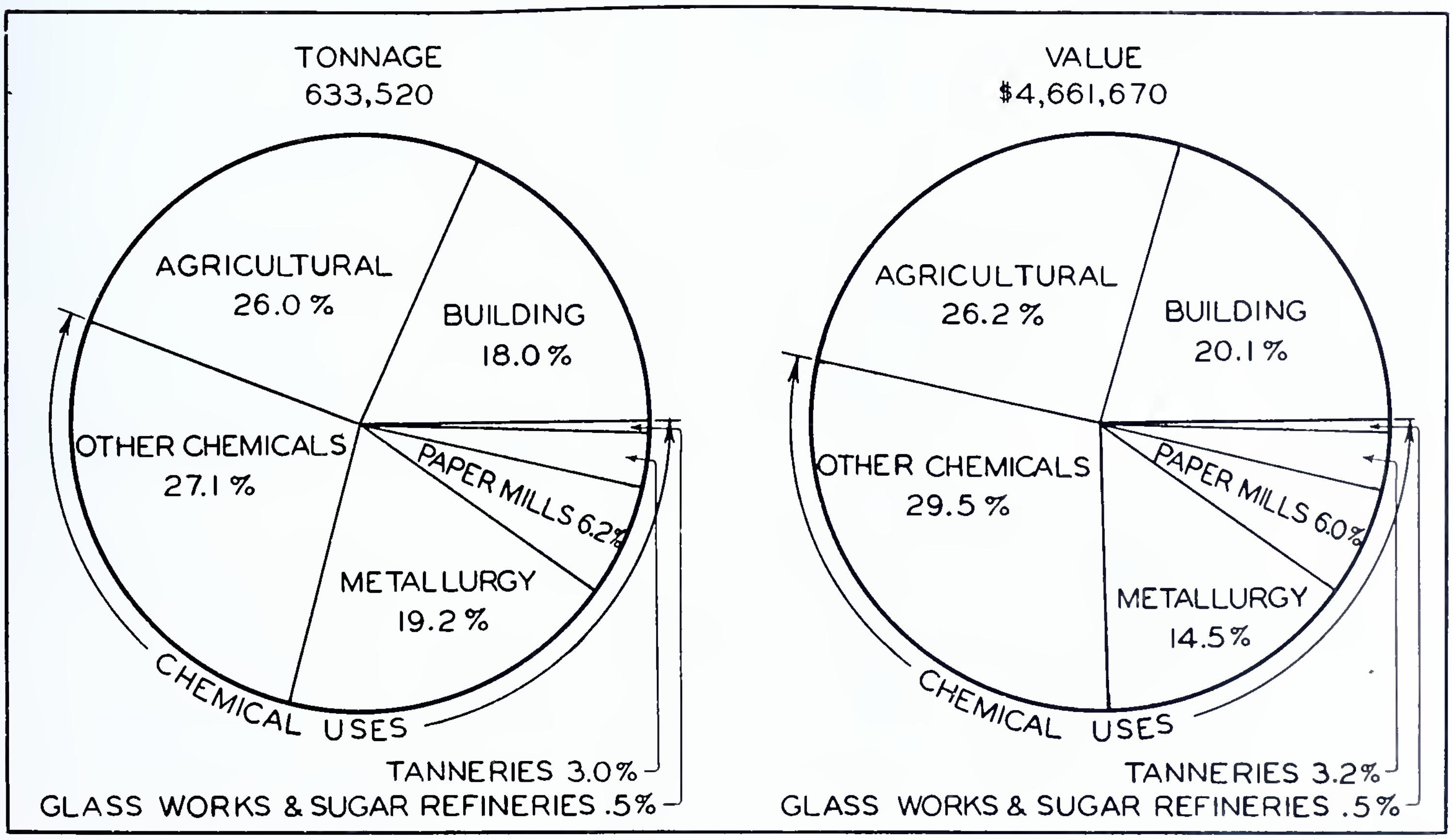

Fig. 79. Uses of lime sold by producers in Pennsylvania in 1930 by tonnage and value. (Data from Mineral Resources of the United States.)

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[1] Miller, Benjamin L., Limestones of Pennsylvania, Pennsylvania Geological Survey, Fourth Series, Bulletin M 7, 1925, p. 346.

[2] Eckel, Edwin C., Cements, Limes and Plasters, 1928, p. 111.

Building Uses

The chief use of lime is in the building trade. Here it is used principally in plaster, both for the first and for finishing coats. Although building trades used only 18 per cent of the lime sold in Pennsylvania in 1930, 36 per cent of the lime produced in the United States was used in this way. This discrepancy is due chiefly to the fact that Ohio, the largest lime producer, specializes to some extent in building lime. Ohio produced 36 per cent of all the building lime sold by producers in 1930, about 60 per cent of Ohio's lime production being sold for this purpose. Pennsylvania was second as a producer of building lime with 9 per cent of the United States total. Ohio's dominance over Pennsylvania in the building lime trade is to be expected since, as already pointed out, Ohio is a much larger producer of hydrated lime and most hydrated lime is used for construction.

After being mixed with sand, hydrated lime is called ''mortar'' or ''plaster''. Though mortar has many uses, its chief one is for plastering walls. ''Plaster'' is defined by the United States Bureau of Standards as any dry material which, when mixed with water, makes a plastic mass that hardens when placed on an interior surface. Thus, the term ''plaster'' includes not only lime mortar, but also, gypsum wall plaster and even Portland cement. Gypsum wall plaster is discussed at the end of this chapter, and the Portland cement industry forms Chapter XII of this report.

According to Miller[3] lime for plaster and mortar comes mainly from the central and southeastern counties of the State.

The building lime industry has unquestionably been affected adversely by the recent enormous increase in the use of Portland cement and the increased use of gypsum wall plaster. Moreover, sales of building lime are closely tied up with the building trade, and, hence, are likely to be seriously affected by periods of depressed business conditions.

Agricultural Uses

Although only 26 per cent of the lime produced in Pennsylvania in 1930 was used for agricultural purposes, the State produced 47 per cent of the nation's total agricultural lime. One hundred and sixty-four thousand seven hundred forty-seven short tons of lime were sold by Pennsylvania producers for agricultural use in 1930.

Agricultural lime is still produced widely throughout Pennsylvania, but, as in the cases of building lime and chemical lime, there is an increasing tendency to restrict its production to fewer and larger plants.

The need for lime in many soils is well known. Some of the purposes which it serves is to convert humic acids into more insoluble form so they are retained in the soil, to prevent injurious bacteria from growing in the soil, to stimulate the growth of nitrifying bacteria, to improve the texture of the soil, and to neutralize an acid condition of the soil. Pulverized limestone may be utilized for these purposes, but it reacts less rapidly than lime.

The production of agricultural lime in the United States should tend to increase in the future. It is often pointed out that much of our American agriculture to date has consisted of ''skimming the cream'', that is, of using up the natural fertility of the land. Fertilizers are coming into increasing use. More and more, such fertilizers as agricultural lime will have to be applied to our lands. Hence, this branch of the lime industry seems to have an assured future.

Chemical Uses

Pennsylvania was the leading State in chemical lime production in 1930 with 19 per cent of the United States total (both by weight and by value). Fifty-six per cent by weight (and about 53½ per cent by value) of the total shipments by lime producers in Pennsylvania were for chemical uses.

The chemical uses of lime are widely distributed throughout the industrial field. Separate figures for classes of chemical uses are available by States and are shown for Pennsylvania in Figure 79.

Many of the chemical uses are very exacting in their lime requirements. Some chemical processes require a very pure, high-grade calcium lime; in others, either a calcium or a magnesian lime may be used. In making magnesium compounds and in the sulphite process of making paper, a high-grade magnesian lime is employed. Refractory lime requires the use of dolomite for its manufacture.

According to Miller[4] most of the chemical lime ''is made from the unusually high grade Cambro-Ordovician limestones of Chester, Lancaster, York, Lebanon, and Centre counties. The Helderberg limestones also yield chemical lime in a few localities, as for example, near Frankstown, Blair County.'' He points out, further, that the extraction of magnesium oxide and magnesium carbonate from high-grade dolomite is a local industry developed in Montgomery and Chester counties. The supply of suitable stone at these localities is probably not large, but such stone occurs at other points in the State.

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[3] Miller, Benjamin L., op. cit., p. 345.

[4] Miller, Benjamin L., op. cit., p. 345.

The Markets For Lime

The markets for lime are different for each of its many uses. Some general statements can, however, be made.

The chief lime-consuming States in order of their importance were in 1930: Pennsylvania, New York, Ohio, Illinois, Michigan, and New Jersey. These States have large cities, considerable industrial development, and, hence, a large amount of construction work. New York State led in the amount of lime received from other States (Figure 80). Pennsylvania, peculiarly enough considering its large production, was second in lime receipts, obtaining 204,972 short tons of lime in 1930 from outside of the State (chiefly building lime from Ohio) and shipping almost an equal amount of lime (239,928 short tons) to other States. Following these two States in tonnage of shipments received from other States came Illinois, New Jersey, Michigan, Ohio, Wisconsin, etc.

In pounds of lime used per capita the order was: Delaware, Maine, Maryland, Pennsylvania, Arizona, etc., the high per capita being determined in some cases by large agricultural use, in others by industrial or building development, and in other cases by still other factors of which large production of lime within the State is particularly

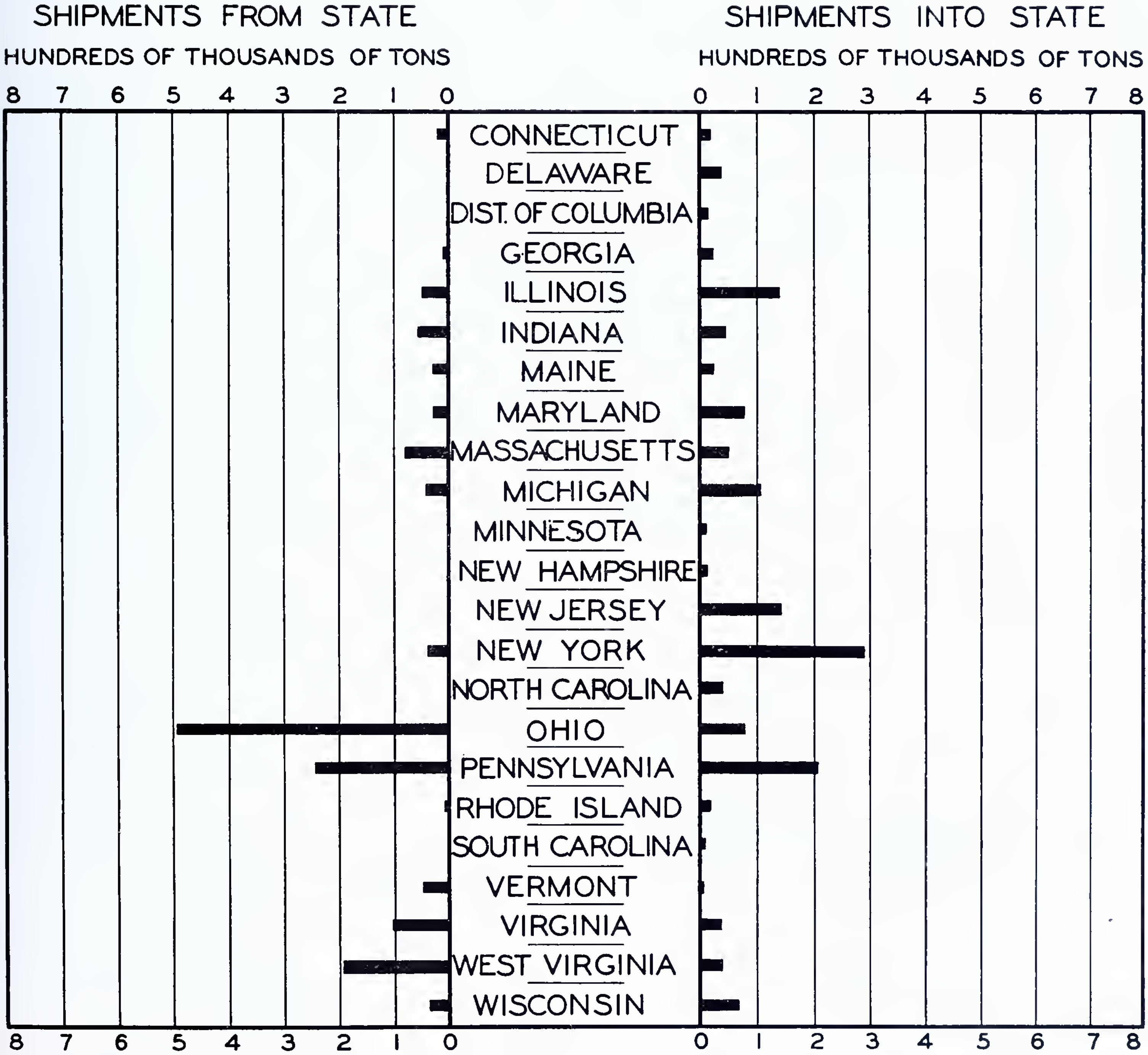

Fig. 80. Lime shipments from and into the various Northeastern States in 1930. (Data from Mineral Resources of the United States.)

important. Thus, a State like Pennsylvania which produces a large amount of lime is likely to have a large per capita consumption, partly because the product is near at hand and hence cheaper than if it had to be brought from a distance, partly because the presence of lime has to some extent attracted lime-using industries, and for other reasons.

Two-thirds of the lime produced in Pennsylvania is used within the State. For the one-third that is shipped out of the State, New York and New Jersey are the largest consumers. Ohio, though a great lime-consuming State, has an even larger lime industry than that of Pennsylvania, and, therefore, does not purchase a very large amount of Pennsylvania lime. The New England States, too, have a considerable lime industry of their own.

The Value of Lime

The value per ton of lime sold varies, of course, with the use. In general, the more exacting the

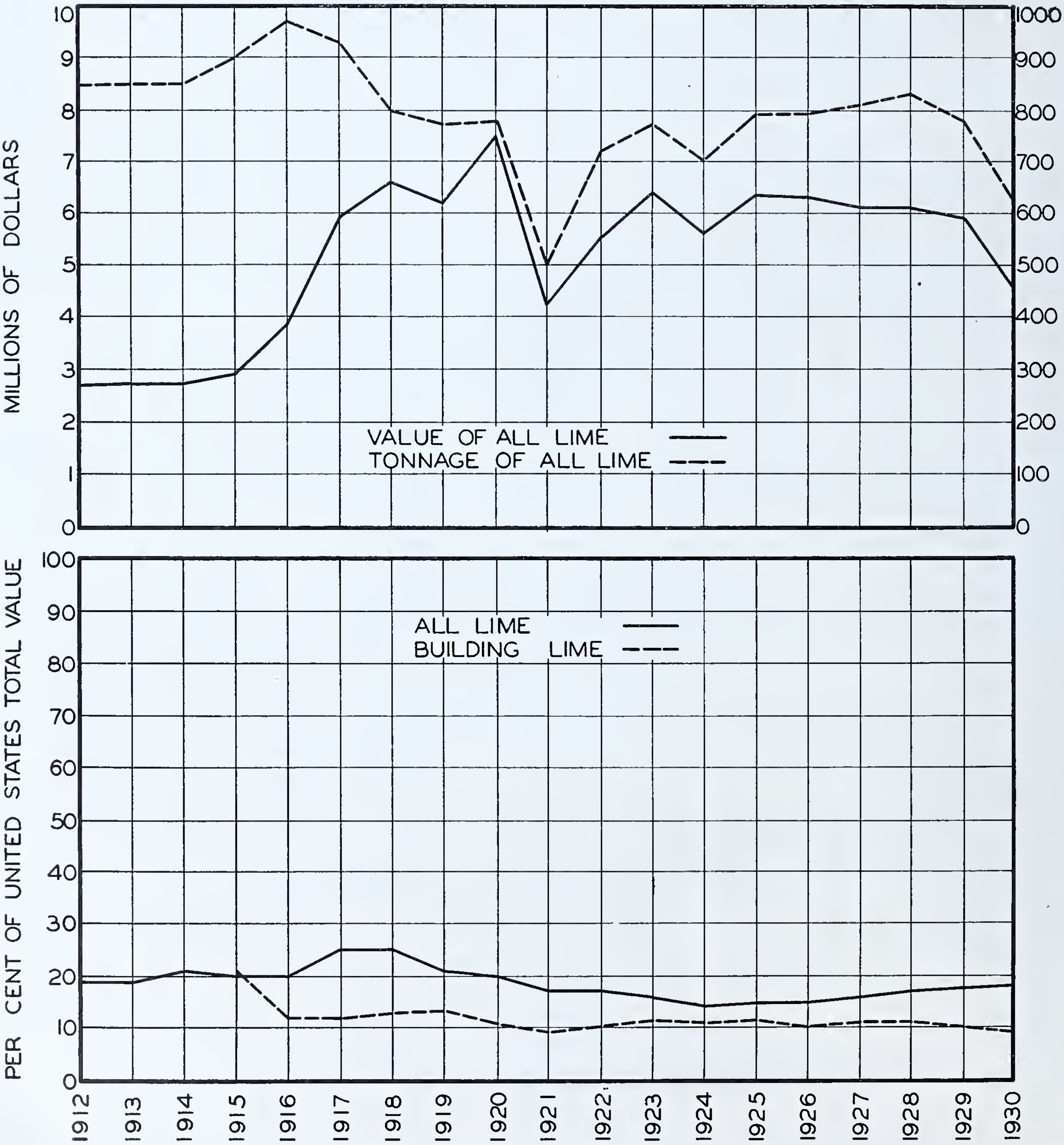

Fig. 81. Recent trends in tonnage and value of lime sold by producers in Pennsylvania and in the State's proportion of the United States total. (Data from Mineral Resources of the United States.)

lime requirement the higher the price. The values per net ton of the principal grades of lime sold in Pennsylvania in 1930 are shown in the following table:

TABLE XI

AVERAGE VALUE PER NET TON OF EACH OF SEVERAL PRINCIPAL GRADES OF LIME SHIPPED BY PENNSYLVANIA PRODUCERS IN 1930 (UNITED STATES BUREAU OF MINES DATA)

Building	$8.20
Agricultural	7.50
Chemical	7.20
Glass works	7.60
Sugar refineries	6.60
Paper mills	7.10
Tanneries	7.85
Metallurgy	5.60
Other chemical uses	8.00
Average, all lime shipped	7.40

Recent Trends In Production and Value

The curves of tonnage and value of lime sold by Pennsylvania producers show a marked slump in 1921 (Figure 81), partial recovery by 1923, and then another decline in 1924. After this second decline, which was less marked than that of 1921, tonnage increased until 1928; but the total value of production, after rising slightly in 1925, has been declining ever since. The drop, both in production and value, was particularly marked in 1930, as was to be expected in view of the generally depressed business conditions of that year.

After a slow decline from 1918 until 1924, Pennsylvania's percentage of the total value of lime produced in the United States has been increasing gradually. During the same 1924 to 1930 period the State's proportion of the total value of building lime produced in the United States showed a net decline of about 2 per cent. Apparently, Pennsylvania has not been holding her own as well in the production of building lime as in some of the other grades of lime.

Exports and Imports

The United States exported 14,536 short tons of lime in 1930, chiefly to Canada, the West Indies, Mexico, and South America. There is a tariff on lime imports amounting to 12 cents per hundred pounds on hydrated lime and 10 cents per hundred pounds on other lime, and this has operated to keep imports at a minimum. The twenty-three thousand seven hundred and thirty tons of lime imported in 1930 passed almost entirely from Canada to our Pacific Coast States, a region which has only meager limestone resources. Neither exports nor imports play important roles in the country's lime industry.

Future of Pennsylvania's Lime Industry

With an abundant supply of limestone there seems every reason to suppose that the State will continue to hold her present prominent position in the lime industry. Indeed, if the demand ever justifies doing so, the lime industry could be greatly expanded. Ultimately, agricultural land in the United States will require the application of much more lime than is now common practice, but this will be a gradual development. The best possibilities for expansion in the near future seem to lie in an increased production of building lime. Ohio produced 36 per cent of the country's building lime in 1930; Pennsylvania only 9 per cent. For the same year nearly 200,000 tons of Ohio building lime were shipped to the Pennsylvania-New York-West Virginia-Maryland-New Jersey-Delaware market area.

Gypsum Plaster

There are no workable deposits of gypsum in Pennsylvania, but the State has a gypsum-products industry producing wall plaster, plaster of Paris, and similar commodities. The raw material for these few plants comes from Nova Scotia (for the Philadelphia industry) and from the gypsum mines of New York State. This manufacturing industry had a total value of products in Pennsylvania in 1930 of a little over $1,000,000.

XII

THE PORTLAND CEMENT INDUSTRY

Introduction

Cement, like lime, is produced by heating limestone to incipient fusion, but the limestones used for lime manufacture are low in clayey impurities, while those used for cement manufacture are high in clayey impurities. With increase in these impurities the burned rock shows a decrease in slaking qualities and develops hydraulic properties, or sets when ground and mixed with water. By far the most important of these "hydraulic" cements is Portland cement. The manufacture of this product is, like the manufacture of steel, an industry in which Pennsylvania not only plays a leading role as a producer, but is the progenitor of developments elsewhere in the United States as well.

Development of the Industry

During the canal building epoch (1817-1860) the manufacture of "natural cement"[1] in New York and Pennsylvania first became significant, the material being used in the water-tight masonry required in the canals which paralleled the streams of these two States. Aside from this use, cement was not then an important building material in eastern United States, for the country was still well supplied with wood, using it for buildings, pavements, sewer boxes, plank and corduroy roads, and bridges, and it was not until after the Civil War that a building boom in the United States created a demand for "Portland cement" which, at that time, was not made in this country. Bigger and better buildings sprang up in the many rapidly growing cities, and miles of sidewalk were laid. Improved city water and sewer systems were installed, while in Washington, Philadelphia, and New York asphalt pavement on a concrete base made its appearance. Cheap European cement was dumped at our Atlantic ports by boats which carried grain and cotton overseas and whose owners were only too glad to have a bulky return cargo. American producers of natural cement were anxious to enter the Portland cement field, but the stationary kiln in use at that time required a great amount of labor which was costly in the United States. It was not until the first rotary kiln was established by the Atlas Cement Company at Coplay, Pennsylvania, in 1889, that the way was found to successfully compete with foreign Portland cement by greatly reducing the labor requirements. By 1900 the imports began to dwindle and American Portland cement, primarily Lehigh Valley cement, came into its own (Figure 82).

Pennsylvania's Place as a Cement Producer

For 40 years Pennsylvania has been the leading producer of Portland cement in the United States, at one time manufacturing more than 75 per cent of the total volume, and, in spite of the great expansion in other States due to westward growth in population, it still produced 23 per cent of the total in 1931. Its closest competitor in that year was New York with a production only one-third as large as that of Pennsylvania. Of the 28,510,231 barrels of Portland cement made in Pennsylvania in 1931 only about one-third was used in the State, the remaining two-thirds going to the neighboring States and abroad. Pennsylvania is the only State of the Atlantic Coast group that makes cement in great excess of its needs, and the North Atlantic States particularly are large users of cement. It is the presence of this large market within a relatively short distance of the Lehigh Valley which has given rise to the concentration of plants in that district.

Importance of the Cement Industry To Pennsylvania

The Portland cement manufactured in Pennsylvania in 1931 had a total value of $30,952,302 and a "value added by manufacture" of about $20,000,000. Approximately 7,900 persons were employed in the Portland cement industry in Pennsylvania in 1930.

The Producing Regions

The Lehigh District

The Lehigh cement district originally covered an area approximately four miles square where the Lehigh River traverses the relatively narrow

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[1] Natural cement is a product made by "burning" a clayey limestone to incipient fusion and grinding the product to a fine size. Portland cement is more carefully prepared, the material which is burned being an artificial mixture containing lime, silica, alumina, and some iron oxide in definite proportions. Portland cement is stronger and more dependable.

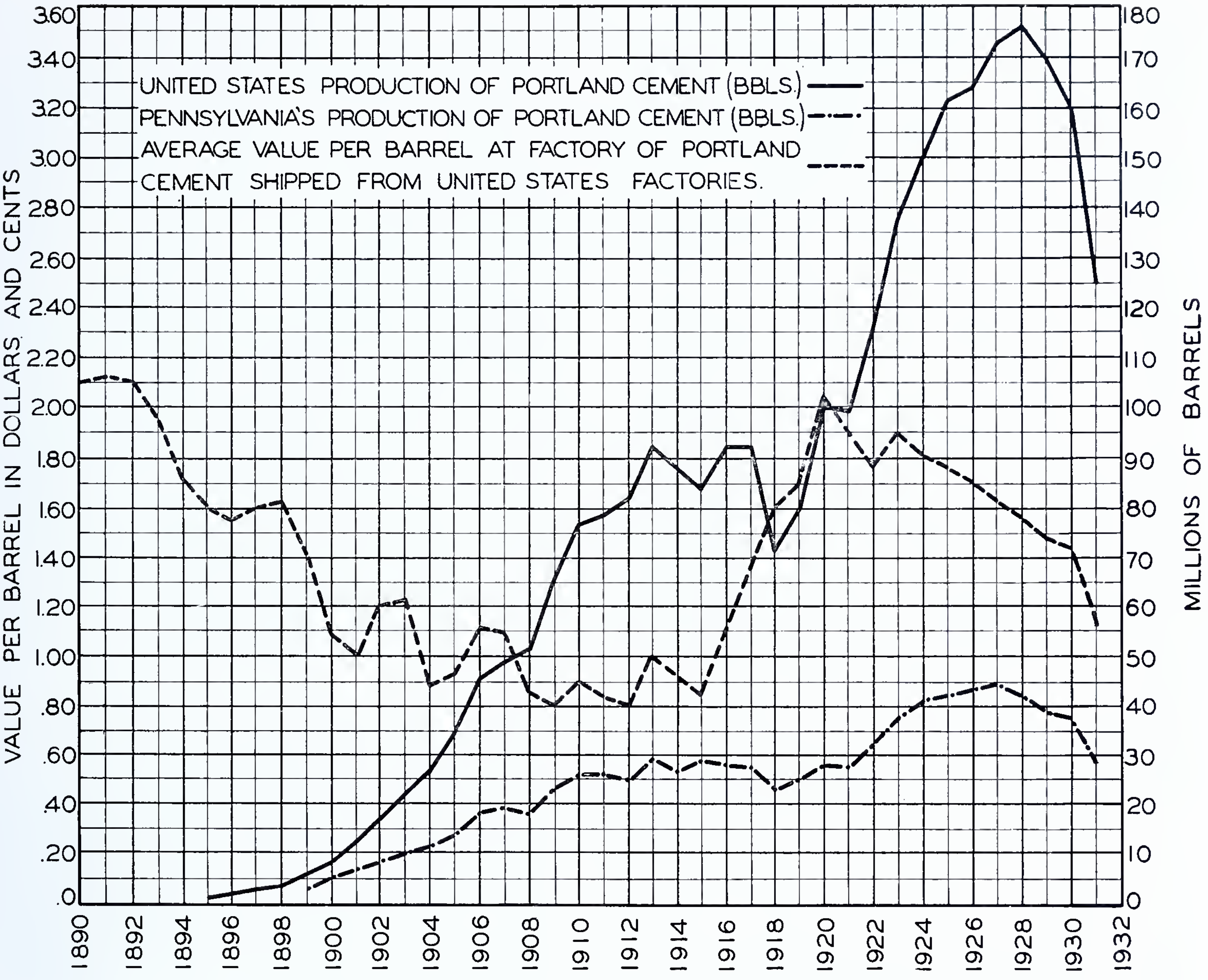

Fig. 82. Recent trends in the Portland cement industry. (Data from Mineral Resources of the United States.)

outcrop of non-magnesian Jacksonburg limestone. Here a formation of clayey limestone, called "cement rock", furnishes a material ideally suited to the manufacture of Portland cement, requiring only a small amount of pure limestone or a little shale to give the desired proportion of lime carbonate to clayey substances. As the demand for Portland cement grew in the eastern centers of population, new cement plants were established at intervals along the outcropping layer to the northeast and southwest until at present there are 22 plants in a region 25 miles long and about 4 miles wide (Figure 58). Two of these plants are in New Jersey and 20 in Pennsylvania. In this small area is made three-fourths of the Pennsylvania product.

Other Cement Regions

Most of the remainder of Pennsylvania's cement production comes from the Pittsburgh district where nine plants are located, some of which use blast-furnace slag as one raw material, and have the advantage of cheap bituminous coal near at hand. There is also one plant near Philadelphia, one at York in York County, and one in Berks County.

Materials Used In Portland Cement Manufacture

The materials which are used in the manufacture of Portland cement in Pennsylvania fall into three groups: cement raw materials, fuels, and small amounts of fluxes and retarders. The first two of these groups are important enough to merit separate discussion.

Raw Materials

Ordinary Portland cement contains about 75 per cent calcium carbonate; 20 per cent silica, alumina, and iron oxide; and the remaining 5 per cent consists of unnecessary but unavoidable impurities. All of these materials are very abundant and widespread. Therefore, availability of raw material alone has not determined the location of cement plants. Location with respect to market (which includes good transportation facilities) and availability of fuel have also been highly important factors, the availability of market being the most important of all.

In the Lehigh district a natural "cement rock" from company-owned quarries is the primary raw material. Nowhere else has a large belt of such perfectly designed cement material been found. Its proportions of 60 to 80 per cent lime carbonate with high percentages of clayey ingredients and less than 8 per cent of magnesian carbonate make it ideal for the production of Portland cement. Where the "cement rock" runs less than 75 per cent lime it is necessary to add small amounts of a nearly pure limestone which is quarried not far away. For the exceptional plant, where the "cement rock" contains a little more than 75 per cent lime carbonate, it is necessary to bring in small amounts of shale, which also is found within a relatively short distance of the mills.

In the Pittsburgh district the cement materials are limestone and clay, and in a few cases blast-furnace slag, which may be had cheaply and in abundance near the steel mills in that part of the State. Where blast-furnace slag is used the cement plant is usually owned and operated by the steel interests as a means of utilizing slag, thus giving rise to the seemingly strange spectacle of an industry undertaking to manufacture two commodities which compete with each other for markets. However, although steel may compete with concrete, concrete, since it requires reinforcing, does not eliminate the use of steel, and the combined product, reinforced concrete, adds to the markets for both commodities. In the Pittsburgh district plants it is necessary to mix considerable quantities of clay with the limestone to get the correct proportions of lime and clay.

The advantages of using "cement rock" as is done in the Lehigh district are obvious. Quarrying can be carried on more cheaply than if two distinct materials were used. It is not necessary to grind the material to such fineness as in the case of artificially mixed batches. It is probable, moreover, that less fuel is necessary. This "cement rock" formed the basis of the rapid growth of the nation's cement industry in the first decade of the present century (Figure 82).

Fuels

"Since in the burning of cement the ash of the coal becomes a part of the clinker, it is allowable to use coals having a medium ash content, as the impurities of the coal are approximately of the same composition as the cement. Sulphur has not been closely limited, as it does not enter into combination with the cement so long as the proper kiln temperatures are maintained.

"Practically all the cement produced in the United States, outside of the natural gas and oil fields, is burned with coal in rotary kilns. The coal is commonly shipped from the mine in slack sizes, and is reduced to a powder just before usage. It is ground so fine that at least 95 per cent will pass through a sieve having 10,000 holes to the square inch. This fine grinding is necessary because of the way the coal is fed to the kilns. Mixed with a proper proportion of air it ignites instantly and is perfectly consumed. A white-hot flame, producing a heat of from 2,500 to 3,000 degrees Fahrenheit, is the result. At this intense heat the raw materials are burned into glass-hard clinkers.

" . . . . . .

"The principal requirements of a fuel for this purpose are that it has a high heating value and that it shall be rich in volatile matter."[2]

The fuel used in Portland cement manufacture in Pennsylvania is largely a powdered, high-volatile bituminous coal. Anthracite and semibituminous coal are slow to ignite and must, therefore, be ruled out. According to Eckel[3] the better coals actually used in cement manufacture range in composition about as follows: 30 to 40 per cent volatile matter, 50 to 60 per cent fixed carbon, 0 to 1½ per cent sulphur, and 5 to 8 per cent ash. A study of the isocarb map (Figure 3) shows that such coals are found only in the extreme western and northwestern parts of Pennsylvania. The cement plants of the Pittsburgh district are plentifully supplied with suitable coal which is mined so near by that it costs very little to bring it to the mill, but the Lehigh district is not so fortunate. The railroad haul to this district is long, and some of the mills find it cheaper to buy West Virginia high-volatile coal than to obtain coal from western Pennsylvania.

"The cost of fuel, burning constantly in a torch 30 feet long, is a vital factor in the manufacture of cement because the consumption is gigantic. For every ton of cement a half ton of coal is burned, so that every day 200 tons or more are consumed [in the United States]. The cement industry is the largest consumer of powdered coal and the fourth greatest industrial user of coal in all forms. The temperature in a rotary kiln is one of the highest in all manufacturing processes; it exceeds the temperature for melting steel, and is greater than that in the crater of Vesuvius when that mountain spumes.

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[2] Keystone Coal Buyers Catalog and Mine Directory, 1930, pp. 52-53.

[3] Eckel, Edwin C., Cements, Limes and Plasters, 1922, p. 452.

"While the major expenditure for fuel is in connection with the kilns, a large amount is necessary for power. Everything about a cement plant is on an exaggerated scale; all the machinery is gigantic and weighted down with materials of enormous tonnage. Hence, to move this machinery excessive power is required. Moreover, all materials are moved from one machine to another by mechanical conveyors; no hand touches cement until the stevedore heaves the bags into freight cars. Therefore, the power facilities of a moderate sized cement plant would serve all the needs of a city of 150,000 people."[4]

A very small amount of anthracite is used in cement manufacture in the Lehigh Valley district, and small amounts of fuel oil are used in cement manufacture in western Pennsylvania. Both fuel oil and natural gas are used in cement plants in the southwestern part of the United States, however, where coal is scarce.

The Manufacturing Process

In the process of manufacture as much hand work as possible has been eliminated. In the Lehigh district great quantities of "cement rock" are blasted down with a single charge, and the rock is scooped up with mostly electric shovels. Crushers of large capacity have been installed which break the large lumps into small fragments, which are mixed with limestone or shale to give the proper proportions and are then passed to gigantic grinding machines. After the various materials have been pulverized they are fed into the rotary kilns where they are converted into hard clinkers which must be repulverized to form cement. The powdered cement is fed into special bags and loaded onto freight cars at a rate of 20,000 bags or more a day.

Uses of Cement

Portland cement manufactured in Pennsylvania is sold largely outside the State, great quantities going to the large consuming markets in New York, New Jersey, and New England. Cement finds a market in, and must be produced near, the large urban centers, for at least 40 per cent of it is used for public and commercial buildings, houses, and sidewalks in urban communities (Table XII).

TABLE XII

ESTIMATED DISTRIBUTION OF PORTLAND CEMENT IN THE UNITED STATES BY USES.

(Based on Estimates of The Portland Cement Association)

	Per Cent	Barrels
Concrete roads, streets, alleys, curbs, and gutters and pavement bases	32.5	57,000,000
Structural concrete in commercial, industrial, public and private buildings of all types	25.0	43,900,000
Rural uses exclusively, including products and all farm structures of concrete	15.5	27,200,000
Concrete products including block, tile and brick, cast stone, stucco, etc., but not products used on farms	7.5	13,200,000
Railways, all uses, including street railways	6.5	11,500,000
Sewerage, drainage, irrigation, culverts, concrete pipe, drain tile and specialties	5.0	8,900,000
Sidewalks and private driveways (exclusive of rural)	4.0	7,000,000
Bridges, river and harbor works, dams and water power projects, storage tanks and reservoirs	4.0	7,000,000
TOTAL	100.0	175,700,000

Another large block is used for highways, which increase in number and width as urban centers are approached, and for paving city streets.

The Price of Portland Cement

The cost of Portland cement production, including preparation for transportation, was analyzed for 1927 in the Thirteenth Annual Report of the United States Tariff Commission. For eastern Pennsylvania, western New Jersey, and Maryland the analysis is shown in Table XIII.

TABLE XIII.

ANALYSIS OF PRODUCTION COST PER BARREL OF PORTLAND CEMENT MANUFACTURED IN EASTERN PENNSYLVANIA, WESTERN NEW JERSEY, AND MARYLAND IN 1927[a].

	Per cent
Fuel	16.4
Power and other manufacturing expense	16.4
Raw Materials	14.3
General and administrative expense	12.2
Selling expense	12.0
Manufacturing labor	11.4
Imputed interest	10.4
Packing and shipping expense	6.9
	100.00

[a] The cost per barrel ($1.42) here analyzed does not include freight. (From data in thirteenth annual report of the United States Tariff Commission, 1929.)

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[4] Keir, Malcolm, Industries of America—Manufacturing, 1928, pp. 507-508.

To the average total production cost of $1.42, transportation charges must be added to get the delivered cost at points of consumption. Thus to Boston, Massachusetts, the transportation cost was $.72 making the total $2.14; a $.38 freight charge made the delivered cost in New York City $1.80; and a $.46 freight charge gave a delivered cost of $1.88 for Philadelphia. Transportation may be seen to have amounted to nearly 34 per cent of the price in Boston; 21 per cent in New York; and 24½ per cent in Philadelphia. In each instance transportation was the largest single item.

The history of the Portland cement price in the United States since 1890 has been an interesting one (Figure 82). At first, as our manufacturers perfected grinding machinery and rotary kilns, and solved the fuel problem, the market price of cement steadily dropped, reaching 81 cents in 1909 and about the same low level again in 1912. This steady fall in price put Portland cement on a par with its competitors, and its superior qualities gave it preference over all others.

Thereafter, with general rising prices, the price of Portland cement increased, reaching a peak of a little over $2.00 in 1920. Increasing production of this much-used material has since maintained a steady decline in the price curve, though the prices of $1.44 in 1930 and $1.11 in 1931 were still considerably above the 1909 and 1912 levels.

Portland Cement Markets

A study of the distribution of cement plants over the whole United States shows them to be invariably clustered about urban centers. Cement is bulky and cheap, and the raw materials necessary for its manufacture are found in many localities. Since the quality has been standardized by the Portland Cement Association, no plant can boast of a better product than another, and the consumer buys on a price basis alone. The factors which go to make up price differences are: the cost of freight, which mounts up quite rapidly (one-third of the factory price for each 100 miles), the cost of fuel, and the cost of obtaining the rock necessary for crushing.

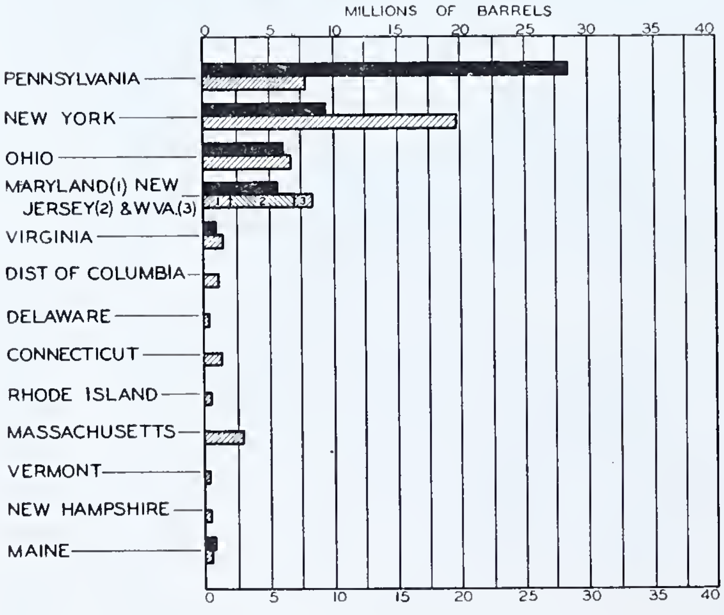

Fig. 83. Approximate production and consumption of Portland cement in Pennsylvania and adjacent states, 1931. Solid bars represent production; lined bars represent approximate consumption. (Data from Mineral Resources of the United States.)

Cement Markets for the Lehigh District

The Lehigh District is well situated to serve the great markets of northeastern United States (Figure 83). Pennsylvania, which consumed 28 per cent of all cement made in the State in 1931, and New York, which consumed about 30 per cent, are the two greatest markets for the Lehigh District product, but New Jersey and New England are also important. In addition to this adjacency to a great consuming area, the District has favorable rates on run-of-mine and slack bituminous coal (although, at such a distance from the producing fields, this item is of course considerable) and it has excellent railroad facilities. But its greatest advantage comes from the fact that it can get "cement rock" so cheaply near at hand and has, therefore, the lowest manufacturing costs in the United States. Lately, however, fuel costs have been increasing, and the plants find that they have greater capacity than they can use economically. They have, moreover, been faced with the danger of losing their markets to foreign competitors.

Competition from Foreign Cement.

It has been pointed out that transportation costs prohibit the shipping of cement for long distances by rail. Therefore, imported cement must be marketed near the seacoast, and competes only with producing districts which are themselves near the coast and in a position to sell to these seaboard markets. The Lehigh District finds important markets in New York, New Jersey, eastern Pennsylvania, New England, and adjacent regions, and it is in these markets that it meets foreign cement.

For a long time after the War, Belgium was the principal source of imports of foreign cement, but in 1931 Belgium was in third place with Denmark and the United Kingdom outranking it. The ability of these countries to market cement on our Atlantic seaboard in competition with the eastern Pennsylvania product is due largely to lower labor costs and less highly mechanized establishments, and, hence, more flexibility in following the variabilities in demand, and lower transportation costs. The distance from the European plants to our Atlantic Coast markets is, of course, much greater than from eastern Pennsylvania plants, but ocean shipment is very much cheaper than movement by rail.

The Tariff Act of 1930 placed a tariff upon foreign cement of 6 cents per 100 pounds including the weight of the container (8 cents per 100 pounds in the case of white nonstaining Portland cement). Within recent years competition from foreign Portland cement producers, particularly European producers, has restricted the foreign market for American cement, and markets are found more and more at home. The 1930 Tariff operates to protect this home market from invasion.

Cement Markets for the Other Pennsylvania Plants

The cement industry near Pittsburgh finds a natural market in the many moderate-sized urban communities of western Pennsylvania, northern West Virginia, and eastern Ohio, as well as in the two or three cities of greater size such as Pittsburgh, Youngstown, and Wheeling. Foreign cement cannot penetrate as far inland as would be necessary to compete with cement made in the Pittsburgh district. Part of the cement manufactured in the Pittsburgh district has the further advantage of cheap water transportation, some 65,000 tons having been carried by river in 1929. The two small plants near Philadelphia and the plant at York undoubtedly find their principal markets in Philadelphia and the urban centers surrounding it.

Per Capita Consumption in Pennsylvania

About one-third of Pennsylvania's 1931 production was used in the State at a per capita rate of .82 barrels. The astonishing thing is that this rate is so low. Not only is the rate lower than that of most neighboring States, but it is lower than it has been in past years for Pennsylvania. In 1925, for instance, it was 1.60 barrels per capita and has been falling off steadily since. The decline is hard to explain, but Pennsylvania is the leading producer of building stone and crushed rock in this section of the United States, and the low per capita may be the result of these materials competing with cement within the State. No doubt, also, some cement held in storage by retailers from previous years was marketed in 1931. Such consumption would not appear in the per capita figure given above, since this is based entirely upon shipments from plants.

Seasonality of the Demand for Cement

Cement is like coal in that demand fluctuates with the seasons. Unlike the case of coal, however, the low ebb of demand for cement comes in mid-winter, in December and January, when building and road surfacing are at a minimum, and spring and summer are the seasons of peak demand. Most cement manufacturing plants do not maintain warehouses large enough to permit a year-round, even production. Instead, they have a large idle capacity for a considerable season of the year in order to take care of peak demand. The slack season serves a purpose, however, since it gives opportunity for overhauling machinery and relining kilns.

Possible Cement Expansion

There are many places in Pennsylvania where suitable cement raw materials occur. The "cement rock" of the Lehigh District outcrops in a more or less continuous band to the southwest across Berks, Lebanon, Dauphin, Cumberland, and Franklin counties and on into Maryland. As the belt of "cement rock" swings farther and farther west and south, it shortens the distance to the bituminous coal fields, but it unfortunately swings farther and farther away from the large population centers, and consequently away from markets as well. By reason of the comparatively low unit value of Portland cement and its proportionately high transportation cost, the price of the domestic product at most competitive marketing points is largely determined by the mill nearest to the specific market. The producer disadvantageously located with respect to large markets must absorb the difference between his transportation cost from mill and that of his competitor nearest to that market.

It is possible that cement plants might operate successfully at some Pennsylvania points along the "cement rock" strip southwest of the Lehigh District. There is a market in the vicinity of Harrisburg (though York, not far away, has a cement industry), but aside from this such plants would have to look southeast for their principal outlets, towards Baltimore and Washington. Moreover, plants already established at Security and Union Bridge, Maryland, and Martinsburg, West Virginia, are better situated with respect to these city markets than any plant that could be developed on the "cement rock" strip in Pennsylvania.

The Nittany Valley in central Pennsylvania has suitable limestones and shales to be used in cement manufacture and the cost of bituminous coal would not be excessive, but adequate markets are not available at present. A cement plant is a large concern, requiring great amounts of capital outlay for equipment and large quantities of fuel and raw materials. It must, therefore, have a large dependable market near at hand and good railroad facilities to carry the cement to its destination.

The Lehigh Valley District is already over-developed, and it may be a long time before consumption again reaches the 1925 peak when the mills of that region were running at 92 per cent of their capacity as opposed to 50 per cent in 1931. Not until the 1925 conditions are duplicated will further expansion in that district seem advisable. Most of the new cement mills built in the State during the last few years have been located in the Pittsburgh district, and it is possible that that region will continue to be the area of greatest expansion.

Problems of the Industry

During the last few years a change in the marketing of cement has occurred which may affect the cement plants profoundly. Formerly, cement was sold directly to the consumer and the cement companies themselves made the contacts necessary to introduce their goods, gave advice as to mixing concrete, and generally superintended its use. Much of this duty is now being taken over by the ready-mix concrete concerns which are springing up in every city. It is their function to buy the cement cheaply and in large quantities directly from the cement companies, mix it with sand and gravel aggregate or crushed stone, and sell it ready-mixed to the building contractor or other user. This process has the advantage of standardizing concrete as well as cement, but it means that the present-day buyers of cement buy more carefully, and cement companies must sell at a lower margin of profit.

Various attempts have been made to organize the cement industry into a solid front similar to that presented by the steel industry, but with only partial success. Keir[5] states that in 1926 the Atlas Portland Cement Company, the largest cement-making concern, had 4 mills in the Lehigh District, 2 in Missouri, and one each in Alabama, New York, and Kansas; the Lehigh Portland Cement Company had 8 plants in Pennsylvania, 2 in Indiana, and one each in Illinois, Iowa, Kansas, Washington, Alabama, and Virginia; and the Universal Portland Cement Company, a subsidiary of the United States Steel Corporation, had one plant near Pittsburgh, 3 near Chicago, and one at Duluth, Minnesota. At the same time there were two other large-scale cement producers, but all five of these leaders together had only about one-third of the total national capacity. Since the industry is so widespread, it has been hard to organize it to the extent that it can have any concerted action. On the other hand, since freight is so important in cost to consumer, the cement manufactured in one district very rarely competes with that made in another district so that a very great degree of cooperation is not necessary.

The Portland Cement Association has done much for the industry. It is one of the largest engineering, educational, and scientific research organizations in the world, and aims to increase the knowledge, utility, and use of Portland cement through scientific investigation and public education. Although it has no function in connection with individual manufacture or sales, it has promoted general sales and extended the demand for cement by its publications and news items furnished to periodicals, by providing instructions to users of cement, and by making staff assistants available for advice on job problems.

There seems to be little prospect of increased markets abroad for cement made in Pennsylvania. With lower labor costs and more ability to follow the curve of demand, plants in western Europe will probably more and more control the markets outside of the United States. At the same time, the Tariff will prevent marked inroads by these foreign producers upon our domestic markets. Thus, the marketing problem becomes primarily one of competition among United States producers for domestic markets.

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[5] Keir, Malcolm, op. cit., pp. 515-516.

XIII

THE GLASS INDUSTRY

The Glass-Making Process

Common glass is made by fusing sodium carbonate or sodium sulphate (salt cake), calcium carbonate (pure limestone), and quartz sand. This mixture is the "batch". Fusing is done in various types of furnaces, which are lined with a refractory clay (called "glass-pot clay"). The batch is heated to a temperature sufficiently high to cause the melting of the three ingredients and their reaction with one another to form glass. Raising the temperature then makes the melt more fluid making it easier for the gas (carbon dioxide) to escape. The soda and lime unite with part of the silica to form silicates, while the remainder of the silica dissolves slowly, increasing the viscosity of the batch. The melt is cooled and poured into the forms desired, or is pressed or blown into these forms by compressed air. Such is the basic process of glass making, but there are innumerable variations incident to the preparation of the various varieties of glass and special glass products.

Development of Glass Manufacture

The American Glass Industry Before 1870

Glass manufacture is one of the oldest crafts in the world, and was the first manufacturing industry introduced into America, appearing in Jamestown soon after 1607. Yet this first craft has been slow to make use of machinery, and even today much glass is made in essentially the same manner as at Thebes in 3500 B. C.

The glass industry of the United States has had an interesting history. Following the short-lived glass works at Jamestown, similar "works" developed elsewhere in the Colonies. Glass works appeared in Massachusetts, Pennsylvania, New York, New Jersey, Connecticut, and New Hampshire, the date of appearance in Pennsylvania being generally accepted as 1683.

"Of all the colonies glass manufacture was most prominent in Pennsylvania. Nearly all the works clustered about Philadelphia and those in western Jersey also served the Quaker City. A plant built in Glassboro, New Jersey, in 1775 by Casper Wistar, was still in operation in 1927; it was the oldest continuously operated factory in America. The reason for the eminence of the craft close to the one colonial metropolis was the larger number of families there who could afford the costly glass; just as today gold dinner sets are more usual in New York City than elsewhere in the nation. Then, too, there were more glass blowers among the German migrants to Penn's colony than in the British colonies, because at the time Germany was ahead of Britain in the industry.

"One of the glass works of Pennsylvania is notable because it was associated with the romantic Baron Stiegel. The plant was on his estate at Manheim and was operated in 1769 by workmen whom the Baron secured from Germany".[1]

Although the glass industry flourished in North America before 1870, it did so with only slight technological changes. Pressed glass manufacture was developed during this period, but this was almost the only advance. Plate glass, though first made in 1852, did not become a commercial success until after 1880. During this early period of the industry the glass factories remained little more than wooden shacks, and the process of glass manufacture simple. The most outstanding characteristic of the period was dependence upon a body of skilled laborers, since the actual making of the various glass objects required was entirely a matter of skill on the part of the workman. This necessary skill together with exacting physical requirements limited the number of glass-blowers, made strong unions possible, and resulted in the glass-blower being an aristocrat among laborers.

Raw materials have never had much bearing upon the location of glass plants. Fuel has been much more important. Wood was the first fuel used in American glass factories, and in the form of charcoal it continued to be important until about 1870. New Jersey was the principal glass-making State of this wood-using period. Soon the use of coal by glass plants began, and, with this change, the western Pennsylvania glass industry began its development, soon outdistancing the wood-glass industry of the East. Pittsburgh became the leading glass-producing city. The discovery of petroleum in western Pennsylvania gave a new impetus to the glass industry newly established in the bituminous coal field. The chief use of petroleum at first was in making kerosene, and the large quantities of illuminant thus made available required a correspondingly large supply of lamp chimneys. Soon it was found that natural gas was the ideal glass fuel. Natural gas is available in the western Pennsylsylvania-Ohio-West Virginia-New York area, and has in some cases been supplemented by manufactured gas.

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[1] Keir, Malcolm, Industries of America—Manufacturing, 1928, p. 530.

The American Glass Industry Since 1870

The period previous to 1870 may be regarded as one of static conditions in the American glass industry. The period following 1870 was one of changes in the industry, changes which are still in progress.

The Regenerative Reverberatory Furnace.

The introduction of gas as a glass fuel with the attendant ease of control made possible the regenerative reverberatory furnace, the first change in glass technology which occurred after 1870. In this furnace the waste gases of combustion pass over loosely piled fire brick which absorbs the heat; then the incoming air and fuel gas is turned through the brick so as to be preheated before combustion. This method is economical in two ways, since it conserves fuel and reduces the time for melting. In this furnace the heat is applied against a curved roof which reflects it upon the object heated. By such indirect heating the danger of contaminating the "batch" of glass raw materials with impurities is reduced.

The Continuous Tank.

Use of a continuous tank was the next innovation. The regenerative reverberatory gas-fired tank permitted continuous twenty-four hour production instead of the previous intermittent output with pots which had to be refilled. The continuous tank replaced pots in all efficient factories except those that made plate glass, superfine tableware, and a diversity of colored ware. By saving time it increased output and increased the earnings both of the employer and of the worker. But the continuous tank paved the way for other inventions which were very largely to replace skilled labor in the industry.

Glass-making Machinery.

There are four main divisions of the glass industry based on four products or groups of products—bottles, building glass (including window glass, obscured glass, and wire glass), plate glass, and blown and pressed ware.

Mechanization of Bottle Manufacture.—In the bottle division, which accounts for most of the total value of glass produced, there has been, since 1900, a steady displacement of skilled labor by automatic devices. The great increase in the bottle business during this period has gone to the plants using automatic machines. While the number of skilled workmen engaged in bottle making is about the same now as in 1900, the relative displacement of skilled labor is startling.

Machinery in the Window Glass Industry.—The early method of "blowing" window glass by hand required much skilled labor. The cylinder method which began to invade the field about 1900 dispensed with the hand blower, but this did not mean a complete displacement of skilled labor as the blower's job was performed by a skilled machine operator. Moreover, the glass trade believed that hand-blown sheets were of superior quality to the machine-blown, so the hand blowers were retained for the better-quality products. In 1916 the Colburn machine appeared. By this process a bar of metal is inserted in molten glass and drawn upward over a roll. The glass is moved forward in a continuous flat sheet and "glass by the mile" is produced. The Colburn machine does away with blowers and all subsequent handlers. Thus, again, as in the bottle trade, the preferred position of labor has been undermined.

Machinery for Making Other Glassware.—Since 1900 machinery has begun to invade other glass-products fields. New machines for making glass tableware and electric light bulbs have had effects similar to those of the Owens automatic bottle-making machine and the Colburn machine in displacing labor.

Transition Stage of Glass Industry.

The foregoing suggests something of the transition stage in which the glass industry finds itself today. About half of the glass-making establishments take full advantage of existing machinery, but the whole industry is changing from hand to machine processes. In its gradual shaking off of the yoke of skilled labor the glass industry is comparable to the pottery industry.

Effect of the World War.

When the World War came, American consumers were depending upon Germany, Belgium, France, and Austria for many of the best grades such as optical glass, glass for scientific purposes, glass for lenses in spectacles, etc. Under the stimulus of the cutting off of European supply our bigger glass companies, through experimentation and investment, began making these higher grades of glass. Thus, though glass was not much in demand as a war material, the War resulted in expansion of the field of the industry.

Specialization and Large-scale Production.

In each of the branches of the glass industry one or more companies have become large-scale producers. If they have but one plant they generally specialize in one variety of glass; where they have subsidiaries, each usually confines itself to one or a very few types of products. Instances of large dominating companies are the Owens Bottle Machine Company in the bottle branch, the American Window Glass Company in the window glass section, and the Pittsburgh Plate Glass Company which is the most important factor in the plate glass division. On the other hand, there are a few large-scale companies that produce a wide variety of products, as, for instance, one Pittsburgh company which markets several thousand objects of pressed and blown glass. The little handicraft factories, which take orders for almost any glass object within their range, constitute another group.

The Present Day Glass Industry Of Pennsylvania

Pennsylvania was the leading glass-producing State in the Union in 1929, with a value of products amounting to $81,050,092 and a value added by manufacture of $50,907,037. It produced 26 per cent of the nation's glass (in terms of value of products). West Virginia, the second State in importance, had a total value of glass equal to about three-fifths of that of Pennsylvania; Ohio, Indiana, Illinois, New York, and New Jersey followed in the order given; and fifteen other States had one or more establishments each.

In total value of products, glass ranked eighteenth among Pennsylvania's manufacturing industries in 1929. In value added by manufacture, which is the real measure of the importance of a manufacturing process, glass ranked tenth, and was second only to iron and steel among the State's mineral processing industries. The Seventh Industrial Directory of Pennsylvania reported 141 glass-making establishments in operation in the State in 1930 with a total of about 18,630 employees.

Branches of the Glass Industry

The principal primary products or groups of such products resulting from the State's glass industry are shown in Table XIV. It will be seen that plate glass and bottles and jars make up more than half of the total value of glass products.

TABLE XIV

INVESTMENT AND VALUE OF PRODUCTION FOR EACH OF THE SEVERAL BRANCHES OF THE PRIMARY GLASS PRODUCING INDUSTRY IN PENNSYLVANIA, 1930. (Based on Seventh Industrial Directory, Pennsylvania Department of Internal Affairs, 1930).

Product	Capital Invested	Value of Production
Glass—bottles and jars	$10,302,600	$21,107,000
Glass—cut	90,400	164,700
Glass—decorative	862,200	1,486,400
Glass—plate	31,075,000	15,742,000
Glass—table ware	3,584,200	4,097,600
Glass—window	8,018,500	3,767,600
Glass—miscellaneous products	13,819,600	15,518,700
Total	$67,752,500	$61,884,000

Raw Materials

According to the United States Census, the principal materials used in the glass industry in Pennsylvania in 1929 (other than fuels) were as follows:

476,451	tons of silica sand
161,471	tons of soda ash
14,575	tons of salt cake
31,587	tons of lime
73,769	tons of limestone

In addition, a large tonnage of grinding sand was used, but for this no separate figure for Pennsylvania is available. Other materials used, varying with the type of glass, include red lead, potash, feldspar, fluorspar, zinc oxide, manganese dioxide, etc.

The character and sources of glass sand, the most critical raw material, have been discussed in the chapter on the common rock industries under "Sand and Gravel."

Fuels

Gas is by far the most important fuel of the glass industry, 97½ per cent of Pennsylvania's active furnace capacity in 1929 being operated on this fuel. Natural gas is available for most of the western Pennsylvania plants, but in parts of the State where natural gas is not available manufactured gas is generally used.

Type of Furnace

Of the furnaces in operation in Pennsylvania in 1929, continuous tank furnaces accounted for 78 per cent of the total capacity; intermittent or day tank furnaces, 3 per cent; and pot furnaces the remaining 19 per cent.

Recent Trends in Production and Value

The first curve of Figure 84 is based on the "value added by manufacture" for each Census year.[2] Despite the fact that the value for 1929 is below those for 1923 and 1919, there seems to have been, nevertheless, an average upward trend during the last three decades. During the same period Pennsylvania's proportion of the United States total has been declining steadily. The State's percentage in 1929, 25.3, was the lowest for any of the Census years.

Another noticeable trend in Pennsylvania's glass industry, as well as the glass industry elsewhere, is toward fewer and larger plants. Thus, while "value added by manufacture" for the State's glass industry was almost 500 per cent greater in 1929 than in 1904, the number of establishments was much smaller. There was a 21 per cent decrease in number of plants in Pennsylvania from 1921 to 1929.

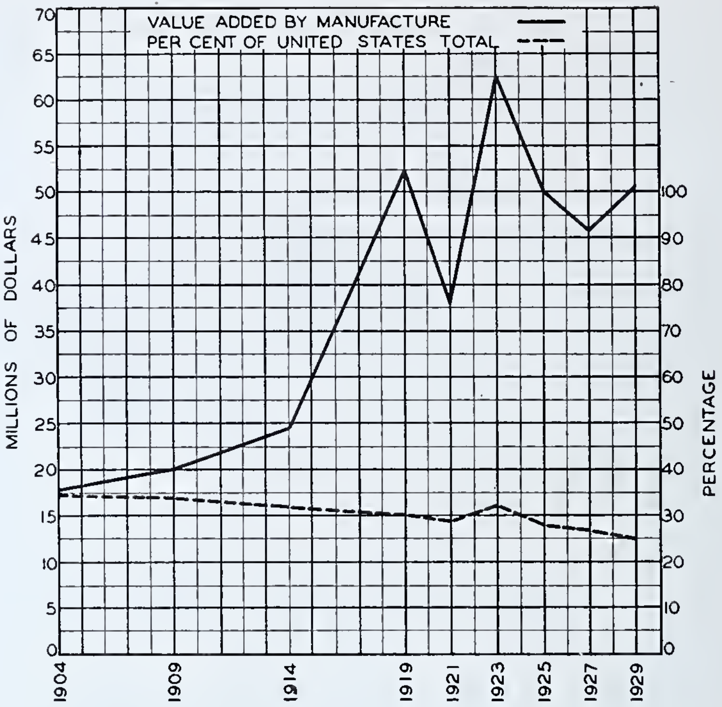

Fig. 84. Recent trends in value added by manufacture of Pennsylvania's glass industry and in the State's percentage of the United States total value added by manufacture. (Data from United States Census.)

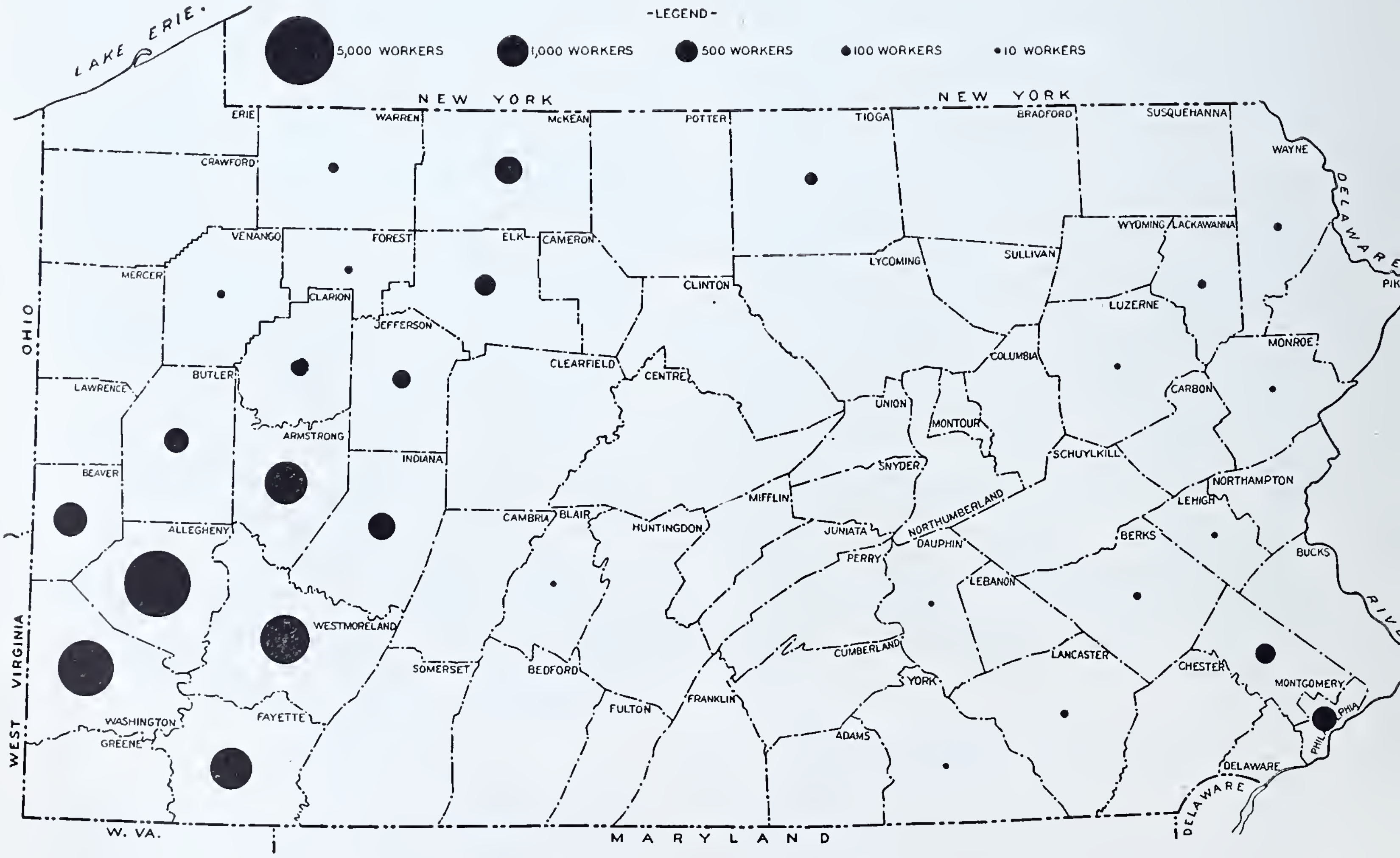

Fig. 85. Map of Pennsylvania showing the number of workers in the primary glass industry in the various counties, 1930. Areas of dots proportional to number of workers. (Based on Seventh Industrial Directory of Pennsylvania Department of Internal Affairs.)

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[2] In the curve showing Pennsylvania's proportion of the United States total, data for establishments with products under $5,000 in value were included for 1919 and prior years but not for 1921 and subsequent years. The discrepancy thus introduced is very small.

Location of Industry in Pennsylvania

Western Pennsylvania.

The major area of glass production is in western Pennsylvania, centering in Allegheny County, but extending in a belt from McKean County on the north to Fayette County on the south and Beaver and Washington counties on the west (Figures 62 and 85 and Table XV). Though determined originally by the presence of coal, the glass industry of this section found natural gas available when that became the favored fuel. Availability of natural gas permitted extension of the area of glass production into the wide belt over which the industry is now spread. Although glass sand is quarried in part of this region, more of the sand comes from central Pennsylvania. A satisfactory fuel is the prime necessity for glass manufacture, and glass sand and other raw materials generally move to a region of cheap fuel for manufacture. Natural gas, which is a particularly desirable fuel, and the coal of the upper Ohio Valley have attracted this industry, and more than half of the glass of the United States is made in western Pennsylvania, West Virginia, and eastern Ohio. Central location with respect to the glass-consuming market is another advantage of this district, since a considerable part of the glass produced is both bulky and fragile and takes high freight rates.

The nature of the products of the glass industry in western Pennsylvania will become evident from an inspection of Table XV. Plate glass, bottles and jars, and miscellaneous glass products are the principal lines of specialization, although table ware and window glass are also of importance, and decorative glass is somewhat less so. The plate glass manufacture is carried on principally in Allegheny and Armstrong counties; the manufacture of bottles and jars in Washington and Allegheny counties; and Westmoreland County is outstanding in window glass manufacture with McKean County second in importance. The table ware industry is scattered over a number of counties, while production of miscellaneous glass is

TABLE XV.

LOCATION OF THE SEVERAL BRANCHES OF THE GLASS INDUSTRY IN PENNSYLVANIA AS SHOWN BY LOCATION OF PLANTS AND THEIR NUMBER OF EMPLOYEES. (BASED ON SEVENTH INDUSTRIAL DIRECTORY OF PENNSYLVANIA, 1930). ONLY PRIMARY PRODUCTS ARE CONSIDERED.

	Bottles & Jars		Cut Glass		Decorative Glass		Plate Glass		Table Ware		Window Glass		Miscel. Glass		All primary Glass	
	Plants	Employees	Plants	Employees	Plants	Employees	Plants	Employees	Plants	Employees	Plants	Employees	Plants	Employees	Plants	Employees
Allegheny	6	691	1	2	14	166	2	2,029	1	600	..	....	8	1,313	32	4,801
Armstrong	1	86	..	..	....	......	1	1,388	..	......	..	....	1	6	3	1,480
Beaver	..	....	1	?	....	......	..	.. ..	1	100	..	....	2	946	4	1,046+
Berks	..	....	..	..	1	62	..	.. ..	..	......	..	....	1	2	2	64
Blair	..	....	..	..	..	......	..	.. ..	..	......	..	....	2	4	2	4
Butler	..	....	..	..	..	....	1	398	..	......	..	....	1	41	2	439
Clarion	2	360	..	..	..	....	..	......	..	......	..	....	..	....	2	360
Dauphin	..	....	..	..	1	15	..	......	..	......	..	....	..	....	1	15
Elk	1	1	..	..	..	....	1	437	..	......	..	....	..	....	2	438
Fayette	1	510	..	..	..	....	..	......	..	......	2	516	3	412	6	1,438
Forest	1	72	..	..	..	....	..	......	..	......	..	....	..	....	1	72
Indiana	..	....	..	..	..	....	1	493	1	198	..	....	..	....	2	691
Jefferson	2	285	..	..	..	....	..	......	..	......	..	....	..	....	2	285
Lackawanna	..	......	..	..	1	4	..	......	..	......	..	....	2	28	3	32
Lancaster	..	......	2	9	1	37	..	......	..	......	..	....	..	....	3	46
Lehigh	..	......	..	..	1	6	..	......	..	......	..	....	..	....	1	6
Luzerne	..	......	..	..	2	20	..	......	..	......	..	....	..	....	2	20
McKean	1	106	..	..	..	....	1	42	..	......	2	340	2	185	6	673
Monroe	..	......	1	7	..	....	..	......	..	......	..	....	..	....	1	7
Montgomery	3	196	..	..	..	....	..	......	..	......	..	....	4	114	7	310
Philadelphia	1	9	3	7	15	112	1	12	..	......	1	147	11	130	32	417
Tioga	..	....	1	6	....	......	..	......	..	......	..	......	1	230	2	236
Venango	1	83	..	..	....	......	..	......	..	......	..	....	..	....	1	83
Warren	1	126	..	..	....	......	..	......	..	......	..	....	..	....	1	126
Washington	2	1,775	..	..	1	61	1	263	1	123	..	......	2	1,090	7	3,312
Wayne	..	....	1	14	..	....	..	......	..	......	..	....	..	....	1	14
Westmoreland	..	....	..	....	1	5	1	7	4	1,224	1	216	4	737+	11	2,189+
York	..	....	..	....	1	10	..	......	..	......	..	......	1	13	2	23
TOTAL	23	4,300	10	45+	39	498	10	5,069	8	2,245	6	1,219	45	5,251+	141	18,627+

concentrated largely in Washington, Westmoreland, Allegheny, and Beaver counties.

Southeastern Pennsylvania.

A second, though considerably less important, area of glass manufacture in Pennsylvania is in, and just northwest of, the city of Philadelphia, particularly in Philadelphia and Montgomery counties. Here the industry is a descendent of the one-time important charcoal-using glass industry of New Jersey and southeastern Pennsylvania. Naturally these plants are handicapped by expensive fuel, but they have been able to keep going partly by specializing in high-grade products and partly because of a favorable location with respect to markets. By reference to Table XV it will be noted that decorative glass and miscellaneous glass products are the most important branches of the industry in this section. There is a small development of plate glass manufacturing, but this is minor as compared with the same industry in western Pennsylvania. The glass industry of this section seems to reflect local demand in Philadelphia and adjacent cities in contrast to the wholesale character of the operations in western Pennsylvania.

Other Glass-Manufacturing Plants in Pennsylvania.

There are a number of other glass plants scattered over the State, most of them small. Almost without exception they specialize in decorative glass, cut glass, or miscellaneous glass.

Future of the Glass Industry

Whether the changes toward large-scale production now in progress in the glass industry will cause any shifts in the location of the industry remains to be seen. Certainly, however, there will be fewer and larger plants in the future. The few plants probably will be those which have the greatest advantages for shipping their products to market or for obtaining fuel.

Porcelain Enamels

Although enameling (the melting of opaque or colored glass upon metal), like glass making, dates back into antiquity, the modern industry is a youthful member of the ceramic group. It is, however, rapidly developing into a very large business. Enamels are used as a coating material on metals with the two-fold purpose of preserving the metal beneath from rust or corrosion, and of beautifying and enhancing the appearance of the enameled product. Enamels are usually used in conjunction with one of three types of metal bases: cast iron, steel, and copper or the noble metals. Enameling of the noble metals has been practiced since long before the Christian Era, but it is the enameling of iron and steel that marks the significance of the industry today, and carries such products into nearly every home in hundreds of uses for everyday life.

"Articles made from enameled cast iron and steel have the properties of great strength and durability imparted to them by the metal, and of easy cleaning, resistance to corrosion, and artistic beauty imparted to them by the enamel. The enameling industry is essentially a combination of metallurgy and ceramics. The production of the metal of proper composition and shape is essentially a metallurgical operation. The finishing of the product by covering the metal with a satisfactory coating of enamel is a ceramic operation. There is a great difference in the processes and in the composition of enamels used in enameling cast iron and steel."[3] The fact that the enameling process and the manufacture of metal goods are so closely allied, makes it almost impossible to obtain any data on the value of enameling alone.

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[3] Shaw, Joseph B., The Ceramic Industries of Pennsylvania, Mineral Industries Experiment Station Bulletin 7, 1930, pp. 102-103.

XIV

THE IRON AND STEEL INDUSTRY

Introduction

Iron has been aptly called the master metal of a metallic age. The cheapness of this metal, which has permitted its wide use, and the great variety of its possible forms, with a correspondingly wide range of physical properties, have been important factors in permitting iron to reach its present eminent position in the industrial world.

Possession of iron goes hand in hand with the possession of coal in prescribing the limits of greatness of countries, since without iron and coal no nation can long maintain a prominent position; and leadership in the world of today is concentrated to a remarkable degree on the shores of the North Atlantic Ocean, where coal and iron occurring near together have made possible the development of great iron and steel industries.

In an era in which national greatness is measured largely in terms of iron and steel production, the United States occupies the favored position of being by far the leading producer of these commodities; producing, in 1930, 33 per cent of the iron ore mined in the world, 40 per cent of the world's pig iron and ferro-alloys, and 44½ per cent of the total world tonnage of steel ingots and castings (Figure 86)[1]. Within the United States, Pennsylvania leads in the iron and steel industry. True, the State produced only 1 per cent of the nation's iron ore in 1931, but she easily dominated the other phases of the industry with 28 per cent of the total pig iron tonnage and 32 per cent of the total tonnage of steel ingots and castings. Ohio, Pennsylvania's nearest competitor in the production of iron and steel from ore, manufactured 23 per cent of the total pig iron and about 25 per cent of the total tonnage of steel ingots and castings during the same year.

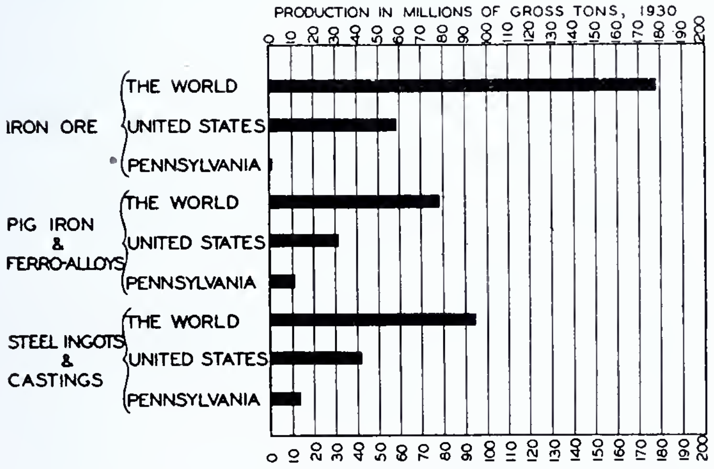

Fig. 86. The World, the United States, and Pennsylvania as producers of iron ore, pig iron and ferro-alloys, and steel ingots and castings in 1930. See footnote below regarding ferro-alloys.

The making of iron and steel (with a total product value in 1929 of $1,493,588,384 and a value added by manufacture of $548,697,674) is by far the State's leading manufacturing industry, accounting for 16 per cent of all value added by manufacture in 1929. In the same year the average number of persons employed by the industry in Pennsylvania, according to the United States Census, was 168,500. The 1930 Productive Industries Report of the Pennsylvania Department of Internal Affairs estimates the capital invested in the iron and steel industry in Pennsylvania as amounting to between 700 and 800 million dollars. But such figures do not by any means fully describe the value of the industry to Pennsylvania. Account must also be taken of the way in which it has attracted or made possible the development of a great many other manufacturing industries. The iron and steel industry of Pennsylvania has been, indeed, the nuclear industry in the growth of a great industrial state.

The Method of Manufacture

The Ore

The average iron ore used in the United States contains (as mined and without drying) between 45 and 55 per cent metallic iron by weight, the other 50 per cent consisting of waste materials and moisture. Most of the iron ore is shipped to the blast furnaces in the condition in which it is mined, but some is beneficiated, that is, screened, dried, hand picked, washed, separated by electromagnetic methods, or otherwise treated to improve the grade of the ore. Beneficiation lessens the amount of waste material upon which freight must be paid.

Whether the ore is beneficiated or not, it is shipped to a blast furnace for the first step in iron and steel manufacture — the production of pig iron.

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[1] In Figure 86 and in a number of later graphs pig iron and ferro-alloys are considered together because they are reported statistically in that way. Since ferro-alloys amount to only two or three per cent of either the State or nation's totals of pig iron and ferro-alloys, the graphs are essentially the same as they would be for pig iron alone if such data were available.

Pig Iron

Pig iron is "a metallic product, the result of blast furnace or electric smelting of iron ores, which is used as part or all of the initial metallic charge in steel making, puddling, and producing molten metal for foundry use".

Production of Pig Iron.

Iron ore is converted into pig iron in a blast furnace. Coke, limestone to act as a flux, and heated air are needed for this process as well as ore; the production of 1,000 tons of pig iron requiring about 1,800 tons of ore, 700 tons of limestone, 1,000 tons of coke, and 4,500 tons of air. Combustion in the blast furnace is promoted by an air blast heated to 1,200 to 1,400 degrees Fahrenheit. Molten iron, the major end product of the operation, is drawn from the furnace at intervals of from 4 to 6 hours. This somewhat impure metallic iron as it comes from the blast furnace is referred to as "pig iron". It may be cast into solid bars or "pigs", or it may be converted directly into steel without being cooled. Although metallic iron is the major objective of the blast furnace operation, a second product, slag, also results. Blast-furnace slag, although still largely a waste product, has a widening field of uses among which may be listed railroad ballast, road surfacing, the manufacture of paving and building blocks, the manufacture of cement in some localities, and, in the case of basic slags, use as fertilizer.

Disposal of Pig Iron.

The pig iron may be used in any one of several ways. It may be made into cast iron in a foundry, into wrought iron in a puddling mill, or it may be made into steel.

Cast Iron and Wrought Iron

Cast Iron.

Cast iron requires a minimum of treatment for its manufacture. Pig iron and cast iron scrap are melted in a cupola at the foundry and poured into a mold of the desired shape, close control of the amounts of phosphorus, sulphur, and carbon being ordinarily unnecessary. Cast iron is, therefore, pig iron which has been cast into molds of some final and useful shape. The greatest fault of cast iron is that it is brittle, but it can be employed where great strength or toughness is not required.

Wrought Iron.

Wrought iron, a tougher product than cast iron, is commonly made by placing pig iron in a reverberatory or puddling furnace and stirring or "puddling" it to remove the phosphorus, silicon, and sulphur. The "blooms" — red hot, solid masses—are then rolled into the desired shapes. A new process, the Byers-Aston, worked out in Pennsylvania plants, makes wrought iron on a large scale by incorporating slag of proper composition into iron previously purified by the Bessemer convertor.

Steel

Steel is iron that contains a definite quantity of carbon, generally less than 1.5 per cent, and owes its characteristic properties chiefly to that element. It is classified for commercial purposes into mild or soft steel, containing less than 0.15 per cent of carbon; medium steel, with 0.15 to 0.30 per cent carbon; and hard steel, containing more than 0.30 per cent carbon. Increase in carbon content increases the hardness and brittleness of steel, but weakens it by a decrease in toughness, malleability, and ductility. There are also numerous "alloy steels" in which various other metals are added to impart special qualities not possessed by "plain carbon steels".

Steel is harder and more elastic than wrought iron, and, at the same time, is suitable for forging and welding when the proportion of carbon is not too high. The properties of hardness, elasticity, and toughness are capable of wide variation through "heat treatment" involving especially "quenching" and "drawing" or "tempering".

The Manufacture of Steel.

Steel may be made by any of four types of processes: the Bessemer, the open-hearth, the electric furnace, or the crucible process.

The Bessemer Process. — The acid Bessemer process (which is the one exclusively used in the United States and the first method by which steel was made on a large scale) is applicable to pig iron of low phosphorus content. Through a modification of the process, the basic Bessemer or Thomas process, iron of very high phosphorus content can be treated. The basic Bessemer process is not, however, used in America. The ordinary or acid Bessemer process consists of blowing air through molten pig iron in a vessel known as a converter, thus oxidizing and removing the impurities. After the "blow" measured quantities of carbon and manganese are added.

The Bessemer process has three major disadvantages: (1) there is a considerable loss of metal due to "spitting" of the convertor during certain periods of the "blow"; (2) due to the short time required for the process the carbon content cannot be absolutely controlled; (3) a great deal of iron ore, in fact most of the ore available in the United States, contains between 1 and 2 per cent of phosphorus, and this ore cannot be used in making steel by either of the Bessemer processes. Chiefly as a result of these disadvantages, only 11½ per cent of the steel made in the United States in 1931 was made by the Bessemer process (Figure 87).

The Open-Hearth Processes. — The open-hearth processes of steel manufacture are slower than the Bessemer process but result in a higher, more uniform grade of steel. The pig iron or the molten product of the blast furnace mixed with steel scrap is placed in a large gas-heated brick chamber, and combustion of gas gives a torch-like flame which plays over the surface of the molten metal producing much iron oxide, which, together with iron ore added to form a basic slag, oxidizes out the various impurities from the molten bath.

The open-hearth furnace may be lined either with silica (acid material) or with magnesite or basic refractory. In the first case, the "acid open-hearth process", only ferrous materials low in phosphorus and sulphur may be used. In the "basic" open-hearth process, on the other hand, a wide variety of materials may be used in this country.

Advantages of this process over the Bessemer lie in the wider range of ores available, in better control of the operation, and in the more uniform quality of steel obtained. About 85 per cent of the steel made in the United States at the present time is open-hearth steel.

Electric and Crucible Steel. — One and six-tenths per cent of the country's steel was made in electric furnaces in 1931, and about .06 per cent by the crucible process.

The Role of Ferro-Alloys.—It has been found that by the addition of varying quantities of such elements as chromium, cobalt, manganese, molybdenum, nickel, silicon, titanium, tungsten, and vanadium[2] steel may be given new or intensified properties that make it tougher, harder, or more resistant to wear or corrosion.

Manganese is more important in steel making than the other elements mentioned. It is used both as an aid in the manufacturing process and as an alloy. In the former case, it acts as a deoxidizer and a desulphurizer; as an alloy it increases the strength of the steel without seriously reducing its ductility. Manganese as ferro-manganese or spiegeleisen is always added in the manufacture of steel, by either the open-hearth or

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[2] These various elements are alloyed with iron and the resulting ferromanganese, spiegeleisen, ferrotungsten, ferrovanadium, ferromolybdenum, or other ferro-alloys are added in making the alloy steels. Nickel and certain other elements may be added in the uncombined state.

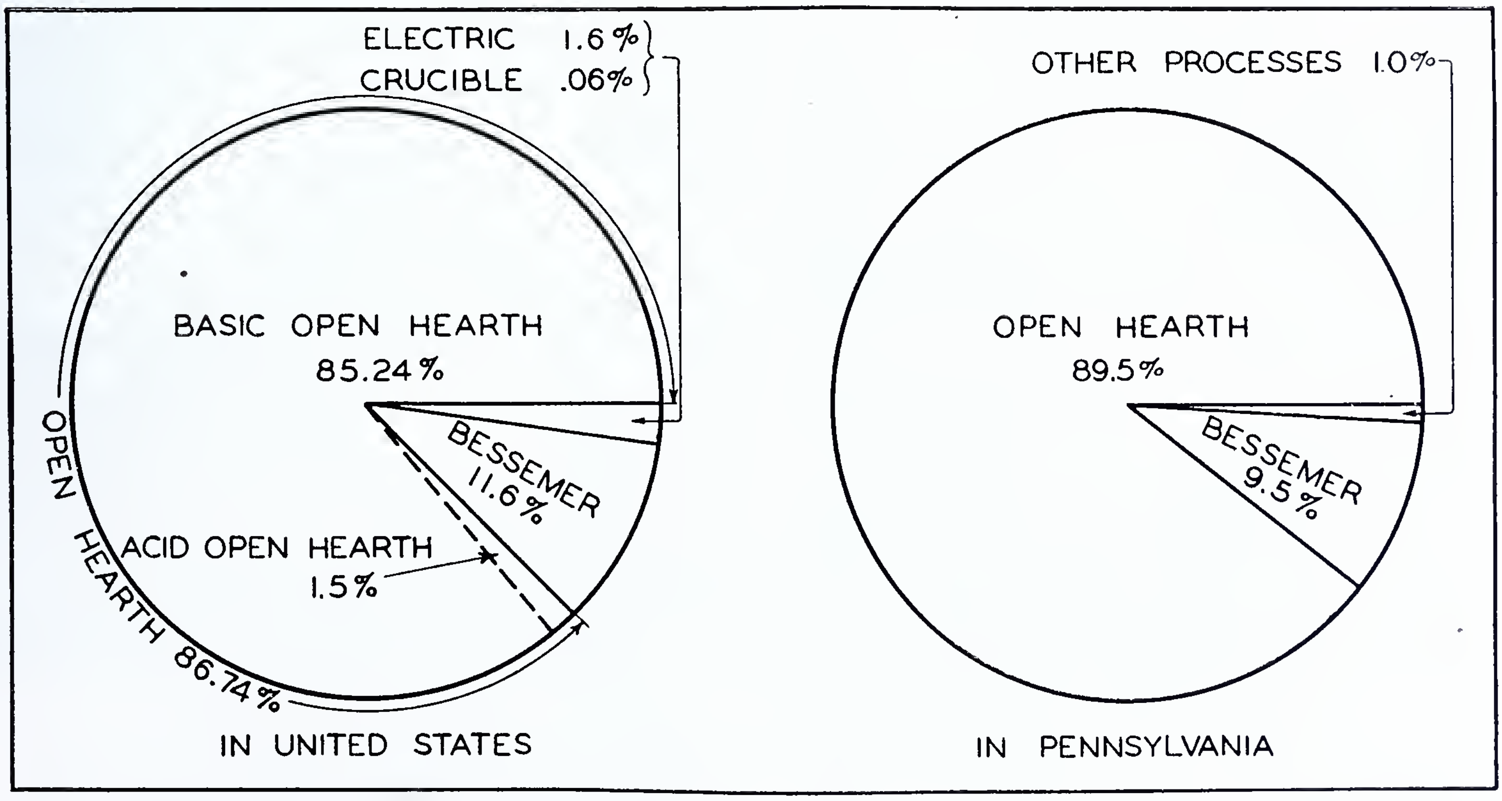

Fig. 87. Processes used in the manufacture of steel ingots and castings in the United States and in Pennsylvania in 1931. (Data from Annual Statistical Report of the American Iron and Steel Institute, 1931.)

Bessemer process, about 14 pounds of manganese being required for each ton of steel made.

Silicon, like manganese, is used as a deoxidizer and purifier as well as an alloy, the former function being the more important.

The Final Stages of Steel Manufacture.—The products of the processes of steel manufacturing just described are steel ingots and steel castings. The castings, which have only about one-thirtieth as large a tonnage as the ingots, enter other industries without further treatment other than annealing; the steel ingots are processed further in rolling mills from which they issue as semi-finished or roughly finished products. The mining of iron ore; the making of pig iron from the iron ore; the manufacture of steel ingots from the pig iron; and further processing of the steel ingots in rolling mills—these are the fundamental processes of the iron and steel industry.

Development of the Iron and Steel Industry

Pennsylvania has long played an important role in the nation's iron and steel industry. It had an important industry in the days of charcoal and local iron ores; it naturally led when anthracite became the important smelting fuel; it leads today with coke as the fuel in a period in which the iron and steel industry has grown to astounding proportions.

The Iron Industry

The Iron Industry at Lancaster.

Iron works were common throughout the Colonies. With the movement of population westward, works sprang up at points in the interior valleys which gave easiest access to markets. The two leaders of this group of iron-making communities in interior valleys were Salisbury, Connecticut, and Lancaster, Pennsylvania.

Lancaster held a strategic position upon routes toward the south and southwest. Not only was this the branching point of the main artery of travel from Philadelphia, but it was the center of a wide agricultural valley as well. More than anything else, the Lancaster industry was a response to this active market, although iron ore, limestone for flux, and forests for fuel (charcoal) were all at hand. Lancaster became the center of an iron-producing region that claimed seventeen furnaces in 1786 and fifty years later over one hundred, at that time ranking among the principal iron-makers of the entire country.

Separation of Smelting and Rolling.

After Salisbury and Lancaster had become firmly established in iron-making, a situation arose which was to be often repeated in the subsequent history of the industry—the smelting of iron ore was separated from the processing of pig iron. Smelting of the ore could be carried on most conveniently where the raw materials were found; the rolling mills and foundries were most advantageously located near the markets, since finished iron articles are bulky, heavy, hard to handle, and relatively expensive to transport. As an example of this division of the industry, Lancaster for a time supplied the foundries and rolling-mills of England with pig iron, shipping it by way of the Susquehanna River and the port of Baltimore.

Movement Across the Alleghenies.

After the close of the Revolutionary War a westward movement of population began, giving an ever extending market for guns and for tools and utensils in that direction. The first furnace west of the Alleghenies was built in 1790 on Jacob's Creek, a small stream which flows into the Youghiogheny River forming part of the line between what are now Westmoreland and Fayette counties. Following this first enterprise, which was known as the Alliance Iron Works, many scattered plants of a similar character developed in western Pennsylvania and farther southwest.

Early Iron Industry of Pittsburgh.

As settlers moved farther westward, the Ohio River was the principal route of travel, and Cincinnati became the major point of debarkation. Roads from north, south, east, and west converged at this city, and it became the common meeting place for the whole great interior between the Alleghenies and the Mississippi. As a result of the large market thus at hand, Cincinnati developed foundries and rolling mills, using iron smelted about 150 miles east of the city at Hanging Rock and Ironton. Pittsburgh, the point where settlers embarked for their journey down the Ohio, had, next to Cincinnati, the best location for an iron and steel industry, and it became important as a rolling-mill center early in the Nineteenth Century. For a long while it had no blast furnaces, obtaining its iron from Fayette County and from the Juniata River district east of the Alleghenies. At first, the Juniata iron traveled entirely by pack trains, but later it utilized the Pennsylvania Canal. The Cambria Iron Company was instituted at Johnstown, Pennsylvania, in

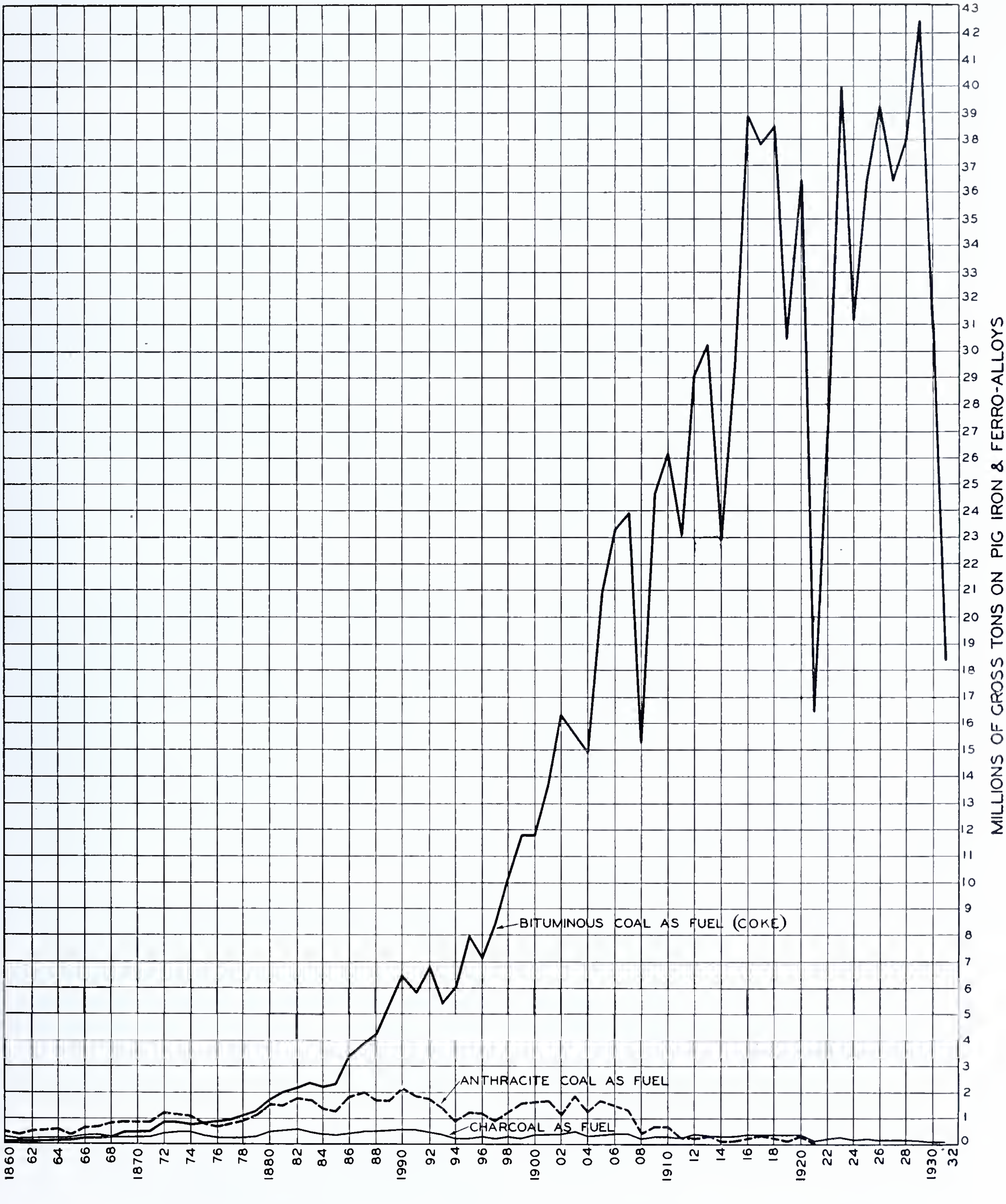

Fig. 88. Trends in the relative importance of the several fuels in the production of pig iron and ferro-alloys in the United States since 1860. See footnote on page 153 regarding ferro-alloys. (Data from annual statistical reports of the American Iron and Steel Institute.)

1841, when the town was head of navigation on the western division of the Pennsylvania Canal.

Growth of Demand in the East.

As manufacturing developed in eastern United States the demand for iron in that section increased. About the middle of the Nineteenth Century railroad development began to make demands upon the iron industry, particularly in the East. More iron was needed than could be supplied. This was met in part by enlarging the capacity of furnaces, but when that was done it became difficult to get enough charcoal.

The Anthracite Furnaces.

As higher furnaces were built the use of a new fuel became imperative and anthracite seemed best suited to fill this need. One of the first plants to manufacture iron commercially with anthracite was the Lehigh Crane Iron Works of Catasauqua, Pennsylvania. By the middle of the Century anthracite was regarded as the principal iron-smelting fuel and it continued so until about 1875 (Figure 88). Most famous of the iron-manufacturing companies that used anthracite for fuel was the Lackawanna, whose original plant was located directly over anthracite coal mines at Scranton, Pennsylvania. The naturally good location of the anthracite region was improved by the building of railroads and canals. Among the towns of eastern Pennsylvania to become famous for iron manufacture during this period were Reading, Harrisburg, Phoenixville, Steelton, South Bethlehem, Danville, Pottstown, and Lebanon. Most of these are still of some importance in the iron and steel industry.

Coke as a Blast-furnace Fuel.

Increase in furnace size made the use of anthracite less and less satisfactory. Anthracite as a fuel was wasteful of draft, crushed and matted under heavy loads of ore, had a high percentage of non-combustible, non-heating elements, lacked uniformity, and was increasing in price.

A careful search for a more ideal fuel resulted in the use of coke. Though coke had been known in England for many years, its use in the United States was delayed by the presence of ample supplies of wood for charcoal and of anthracite. The real development of the coke industry began about 1860 when Connellsville coke was used for smelting iron.

Lake Superior Ore.

Larger furnaces and better fuel called for a larger amount of high-grade ore than was formerly available. This need was met by shipments from deposits near Lake Superior in Michigan, and later in Wisconsin and Minnesota. Though the first ore from the Lake Superior region was brought into Pennsylvania in 1853, regular shipments did not begin until after the opening of the Soo Canal in 1855.

The Growth of Pittsburgh as an Iron Center.

With the change to Lake Superior ore and the shift from anthracite to coke, new, larger furnaces developed, and Pittsburgh was the natural place for their development. The city was about halfway between the extremes of the eastern and western markets; it had excellent rail connections eastward and rail and water routes west; it was adjacent to the best coke in the world; Lake Superior ore could reach it easily and cheaply; it had a long-established rolling mill industry; and, lastly, it was already organized to market iron products. With all of these advantages it is not surprising that Pittsburgh became the great center of the iron industry and later of the iron and steel industry.

The Rise of Steel

The Demand for a Better Product.

As the quantity of iron manufactured increased sufficiently to meet demands, there began a cry for better iron. Iron rails failed under the weight of larger locomotives and longer trains. Architects needed a new material to build taller buildings. Steel, which had been known and manufactured in small quantities for a long time, seemed to fill the need, but it was too expensive for wide use. Cheap steel was needed and this need was finally met by the development of the Bessemer process (See page 154).

The Bessemer Process.

The first Bessemer works erected in this country were at Troy, New York. The second installation was at the plant of the Pennsylvania Steel Company near Harrisburg, Pennsylvania (at what is now Steelton). There, in 1867, steel was poured which was rolled into the first steel rails commercially manufactured in the United States, the Cambria Iron Company at Johnstown doing the rolling.

Bessemer steel grew rapidly in popularity in the last quarter of the Nineteenth Century, and soon supplanted iron for a great many uses.

Open-hearth Steel.

After twenty-five years of Bessemer steel there began a clamor for better steel. Bessemer steel was too weak for the work it had to do. Though cheap it was not uniform in grade.

"Open-hearth" steel, made by a slower and more costly method than Bessemer steel, began to replace the latter. So complete has been this shift (Figure 89), which began about 1897, that in recent years about 85 per cent of the country's steel has been open-hearth. The basic open-hearth has been found especially well adapted to American conditions.

Recent Growth of the Industry

The rise of the iron and steel industry since 1880 and particularly within the present century has been indeed phenomenal. From about 13 mil-

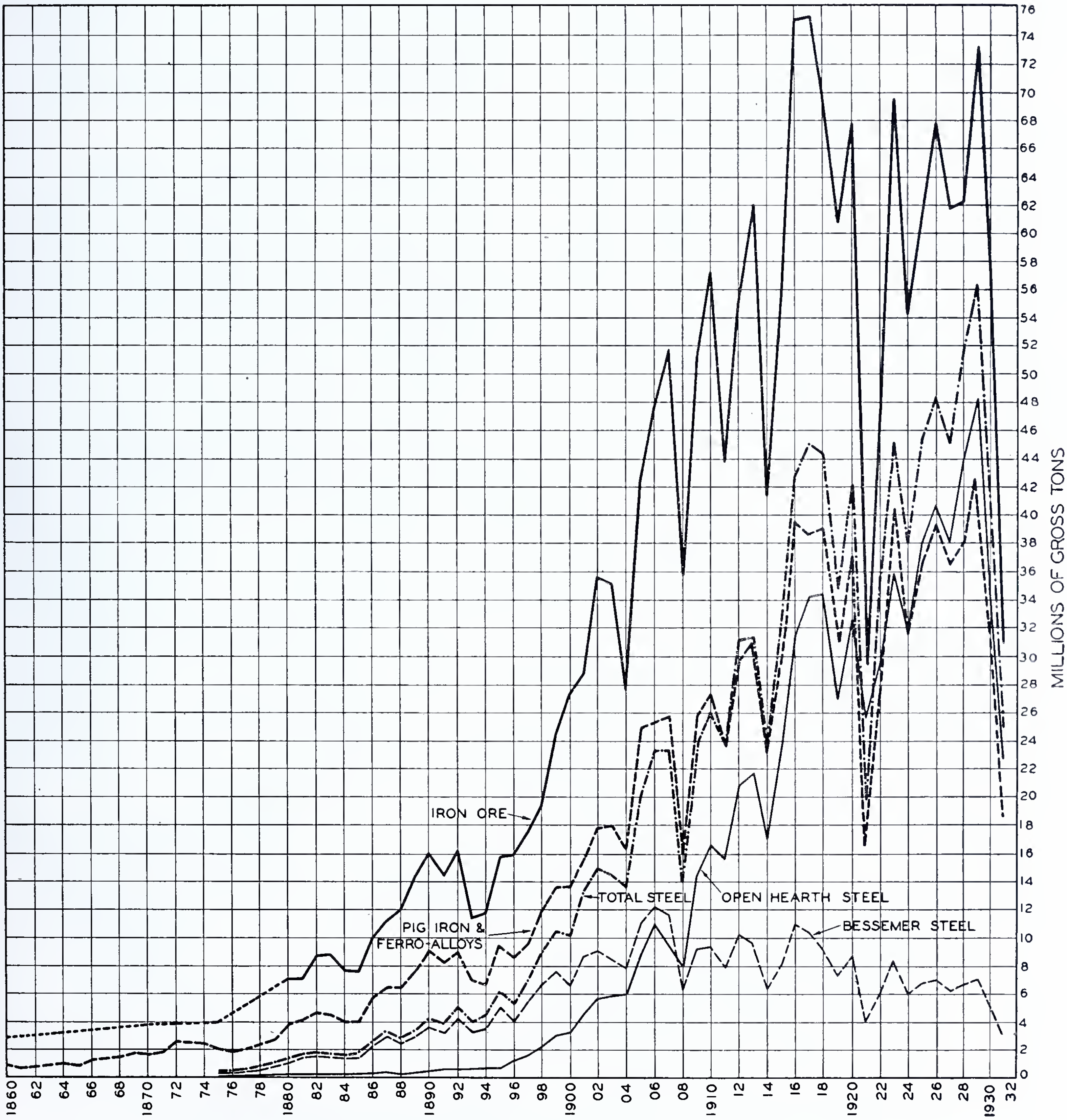

Fig. 89. A graphical picture of the rapid growth of the iron and steel industry in the United States, and of the shift from Bessemer to open-hearth steel. See footnote on page 153 regarding ferro-alloys. (Data from annual statistical reports of the American Iron and Steel Institute.)

lion gross tons[3] in 1900, the pig iron production of the United States had mounted to nearly 42 million in 1929. During the same period total steel production rose from 10 million to 56 million gross tons, and total finished rolled iron and steel from 9½ million to 41 million.

Integration of the Industry

Coincident with the phenomenal rise in the production of iron and steel has come integration of the iron and steel industry. In the early days of the industry mergers were undesirable even where many of the units belonged to the same persons, because, as separate organizations, the units could furnish working funds for each other by issuing notes that might be discounted at the banks. By about 1890 the iron industry had become so firmly established that this use of credit was unnecessary. The inefficiency of keeping apart related plants became apparent, and the various parts of the industry began to coalesce. Rolling mills absorbed furnace companies and amalgamated with fuel and ore producers. When all the stages of production from mining of the ore to finished rails, beams, or plates were consolidated, there followed an attempt to bring into the combine the most important secondary producers such as wire mills, tube factories, and the like.

Out of these early mergers and consolidations have grown the great iron and steel companies of today. Eighty-nine per cent of the ingot capacity of the United States was controlled by ten companies at the end of 1931[4]. According to the annual statistical report of the American Iron and Steel Institute, the United States Steel Corporation, the largest of these concerns, controlled, in 1931, 43.3 per cent of the ore shipped from all mines in the United States, 20.9 per cent of the coke produced, 38.1 per cent of the pig iron and ferro-alloys, 38.9 per cent of the steel ingots and castings, and 34.2 per cent of all kinds of finished rolled products. The Bethlehem Steel Corporation has about one-third as large a capacity as the United States Steel Corporation.

Following these two in size among the first ten were, in 1931, the Republic Steel Corporation, the Jones and Laughlin Steel Corporation, the Youngstown Sheet and Tube Company, the Inland Steel Company, the American Rolling Mill Company, the National Steel Corporation, the Wheeling Steel Corporation, and the Corrigan-McKinney Steel Company.[5]

As will be pointed out again later, the United States Steel Corporation and the Jones and Laughlin Steel Corporation are the largest iron and steel concerns in extreme western Pennsylvania; the Bethlehem Steel Company (the chief operating subsidiary of the Bethlehem Steel Corporation) is outstanding in eastern Pennsylvania; and both of the larger companies are represented at Johnstown, Pennsylvania, although the Bethlehem Steel Company has the larger interests there.

Steel-Consuming Industries

The major end product of the iron and steel industry is steel. What becomes of this finished steel? Three industries are of outstanding importance in their use of the commodity. One of these, building and construction, used 16 per cent of the country's total in 1932 (Figure 90); second, the automotive industry, used 17 per cent; and the railroads were third with 12 per cent.

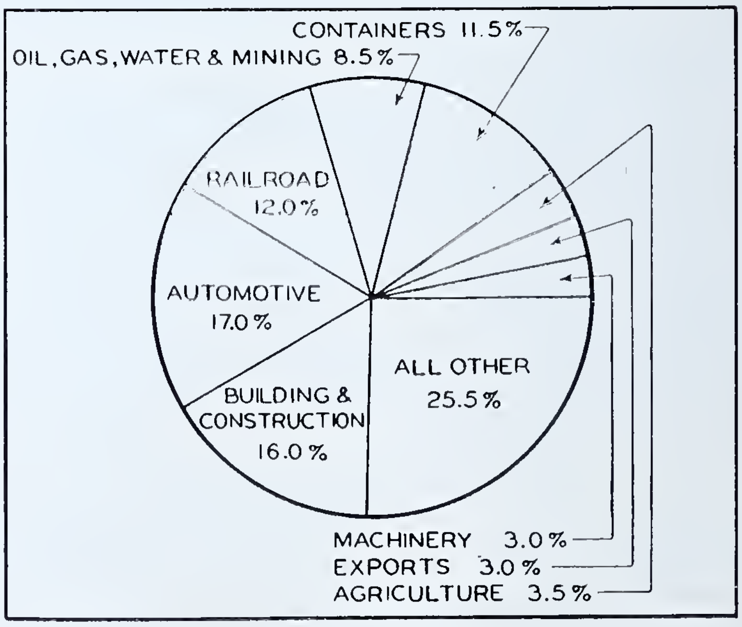

Fig. 90. Industries consuming finished steel in the United States in 1932. (Data from The Iron Age.)

Location of the Iron and Steel Industry in the United States

As background for a discussion of Pennsylvania's iron and steel industry, it is first necessary to give a general picture of the distribution of the industry in the United States.

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[3] The "ton" of the iron and steel industry is the "gross ton" or "long ton" of 2240 pounds, in contrast to the "net ton" or "short ton" of 2000 pounds commonly used in other industries.

[4] Herrick, George S., in The Mineral Industry during 1931, p. 270.

[5] Herrick, George S., op. cit., p. 270.

Iron Ore

The iron ore used in the nation's iron and steel industry comes mainly (about 83 per cent of the United States total in 1931) from the Lake Superior Region—Minnesota, Michigan, and Wisconsin—but Birmingham, Alabama, is an important producer (about 11 per cent), and there are a number of minor producers which include Pennsylvania with 1 per cent, New York with .9 per cent, Wyoming, Utah, New Jersey, etc. Imports, equivalent to about 5 per cent of the nation's production, come chiefly from Chile, Cuba, Sweden, and North Africa.

Pig Iron

About 28 per cent of the pig iron manufactured in the United States in 1931 was made in Pennsylvania; 23 per cent in Ohio; 23 per cent in Indiana, Illinois, and Michigan at the south end of Lake Michigan; 9 per cent in the Birmingham, Alabama, District; 6 per cent in New York, chiefly in and near Buffalo; 4 per cent in Maryland (at Sparrow's Point); and the remainder in ten other states.

Steel Manufacture

Steel manufacture is carried on in approximately the same localities as the making of pig iron. Pennsylvania made 32 per cent of the country's total steel ingots and castings in 1931, Ohio 25 per cent, Illinois and Indiana 19 per cent, while smaller producers included New York, Maryland, Alabama, West Virginia, and twenty or more other states. Further processing of the steel ingots in rolling mills is usually associated with the plants making ingots. The distribution of this activity by states is, therefore, much the same as that of the earlier stages of steel manufacture.

The Iron and Steel Industry in Pennsylvania

The general distribution of the iron and steel industry within Pennsylvania is shown in Figures 91 to 94. On each of these maps it will be seen that a rough division may be made between the industry of western Pennsylvania and that of eastern Pennsylvania, since there is a belt in between with little iron and steel development.

Eastern Pennsylvania

The iron and steel industry of eastern Pennsylvania is less important than that of the western half of the State, accounting, as it did, for only 16.3 per cent of the State's pig iron total in 1931

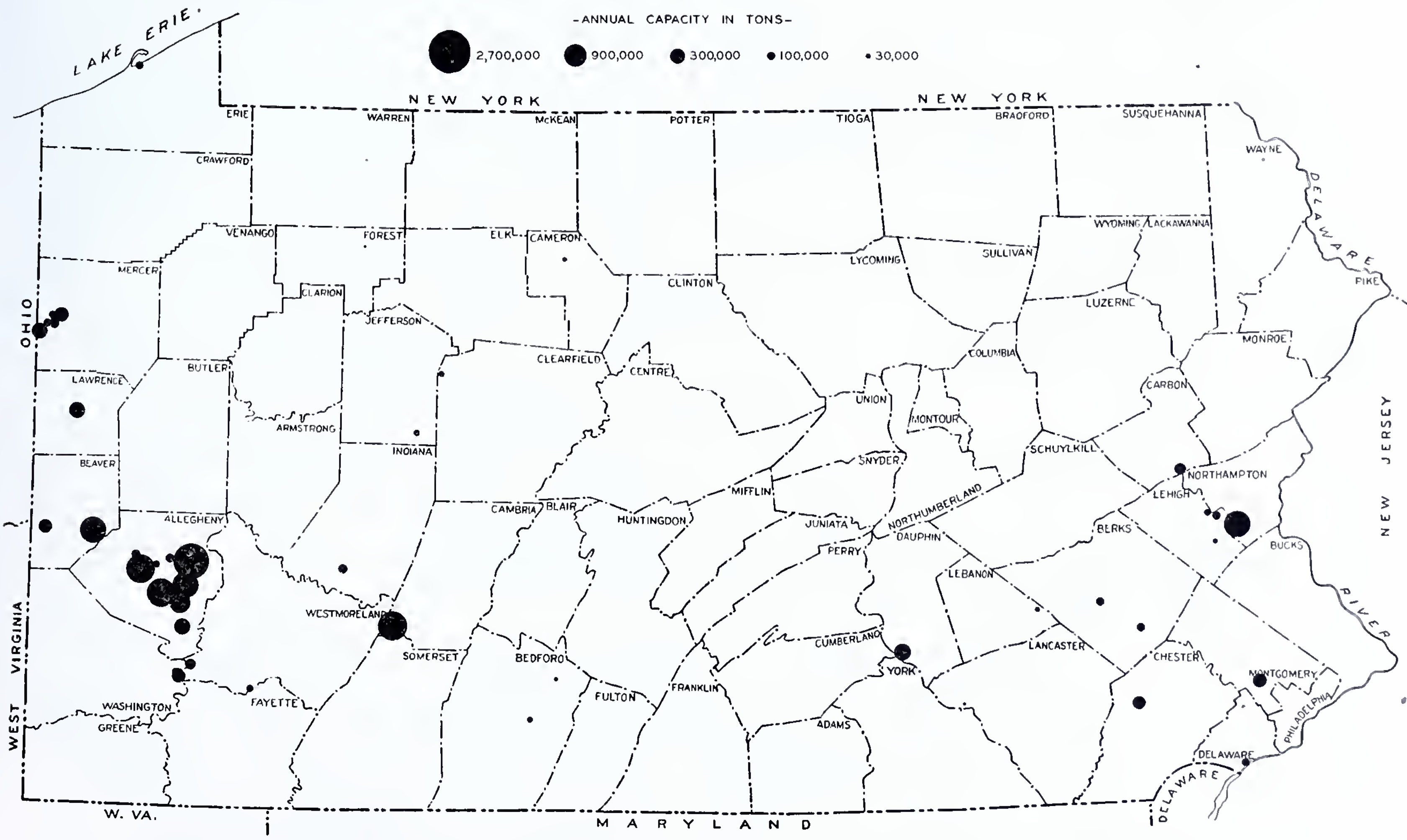

Fig. 91. Location and capacity of blast furnaces in Pennsylvania, as shown in the American Iron and Steel Institute's Directory of the Iron and Steel Works of the United States and Canada, Twenty-first edition, 1930.

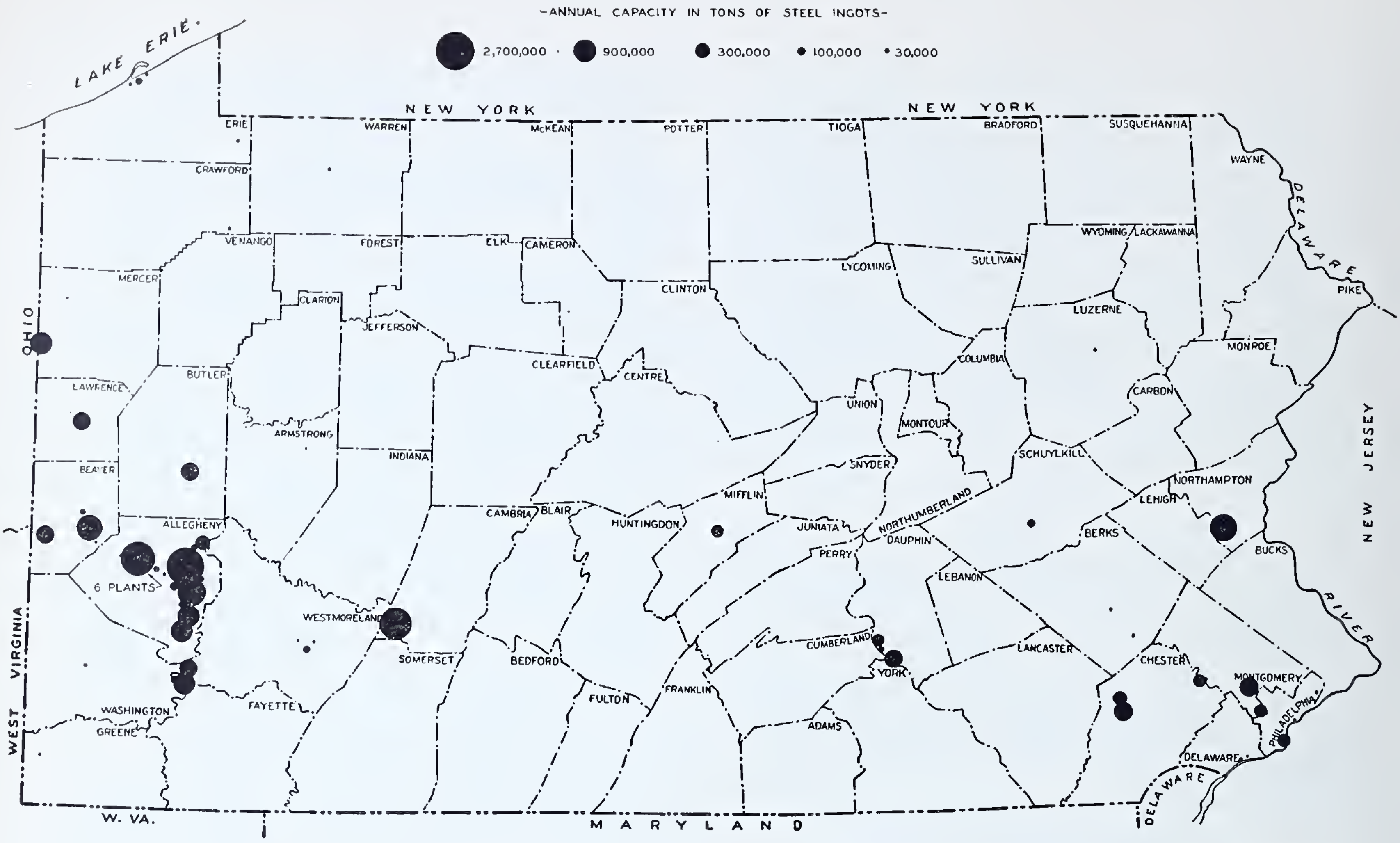

Fig. 92. Location and capacity of plants making steel ingots in Pennsylvania, as shown in the American Iron and Steel Institute's Directory of the Iron and Steel Works of the United States and Canada, Twenty-first edition, 1930.

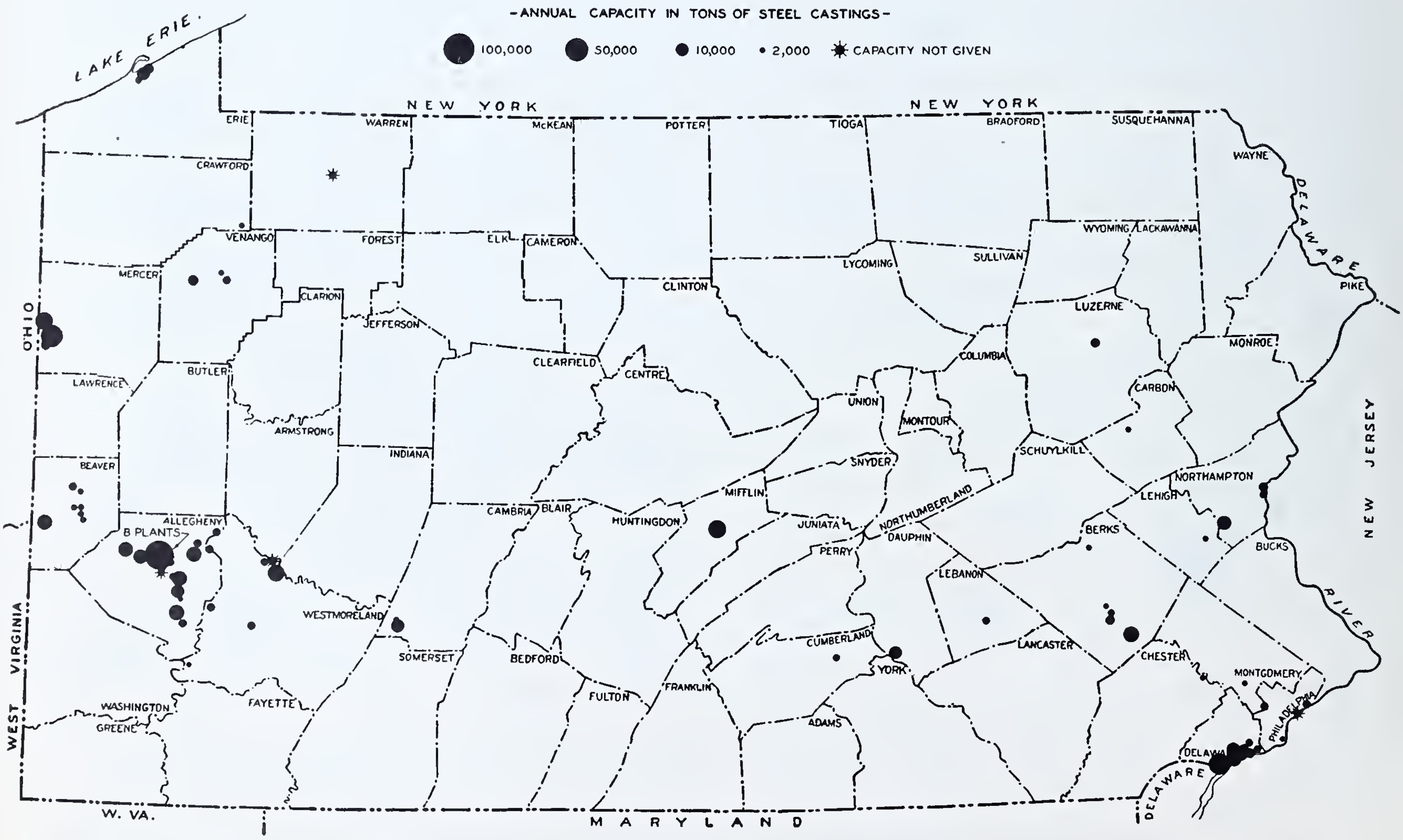

Fig. 93. Location and capacity of plants making steel castings in Pennsylvania as shown in the American Iron and Steel Institute's Directory of the Iron and Steel Works of the United States and Canada, Twenty-first edition, 1930.

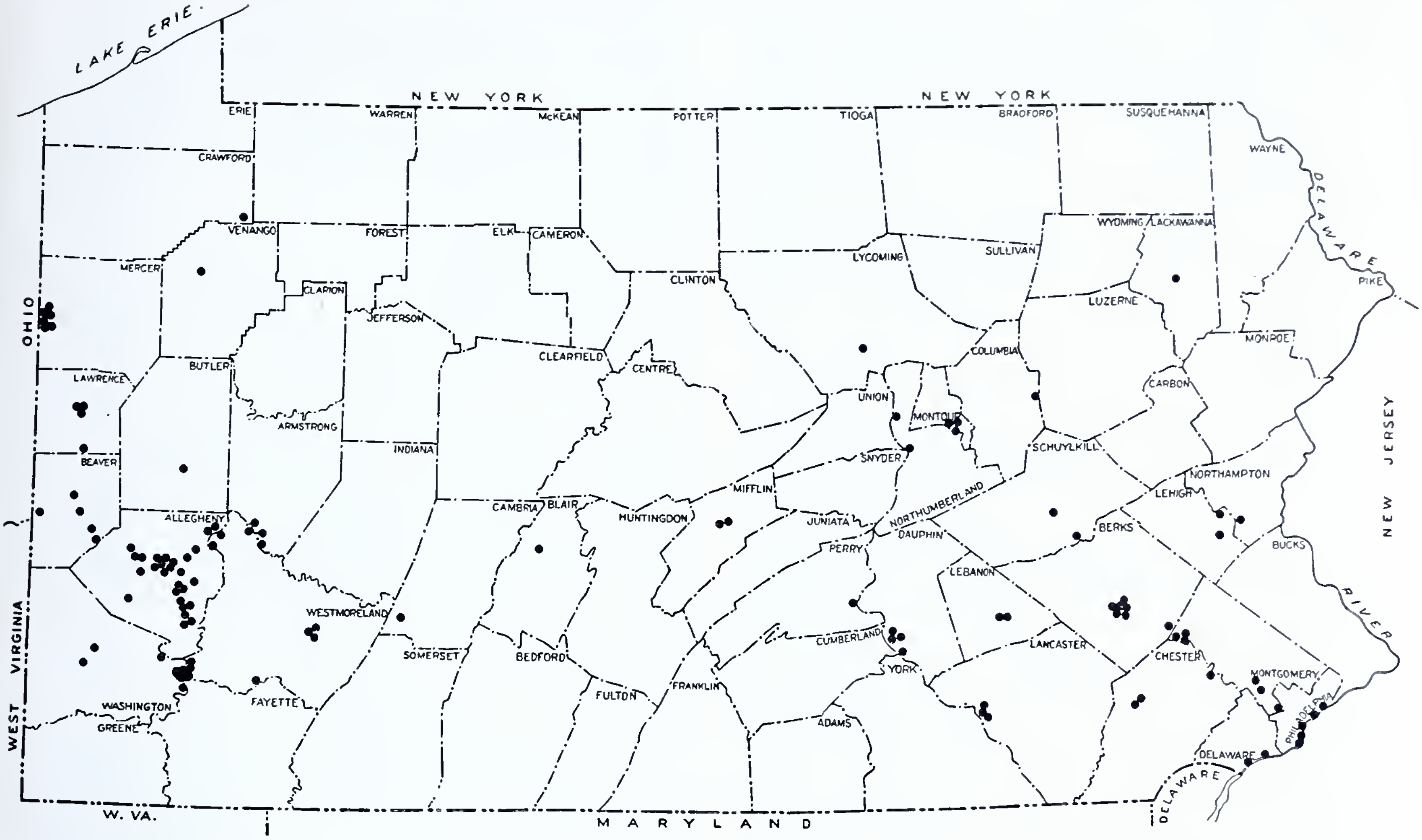

Fig. 94. Rolling mills in Pennsylvania as listed in the American Iron and Steel Institute's Directory of the Iron and Steel works of the United States and Canada, Twenty-first edition, 1930.

and only 20.8 per cent of the finished, rolled iron and steel (Figures 95 and 96).[6] The eastern Pennsylvania industry is, moreover, less concentrated. There is an outstanding center of the industry in eastern Pennsylvania, Bethlehem, but it does not represent as great a degree of concentration of all phases of the industry as does Pittsburgh in the west.

Eastern Pennsylvania is of greater relative importance as a producer of finished rolled iron and

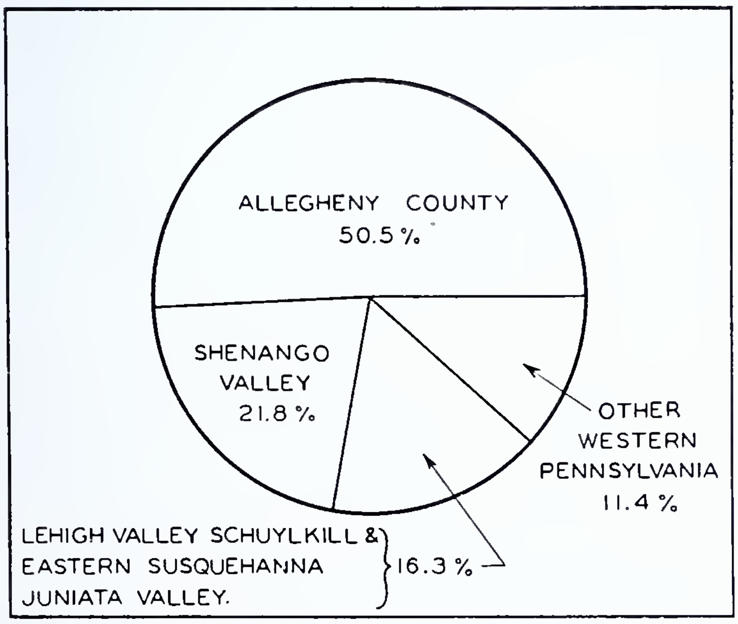

Fig. 95. Production of pig iron in Pennsylvania by districts, 1931. (Data from Annual Statistical Report of the American Iron and Steel Institute, 1931.)

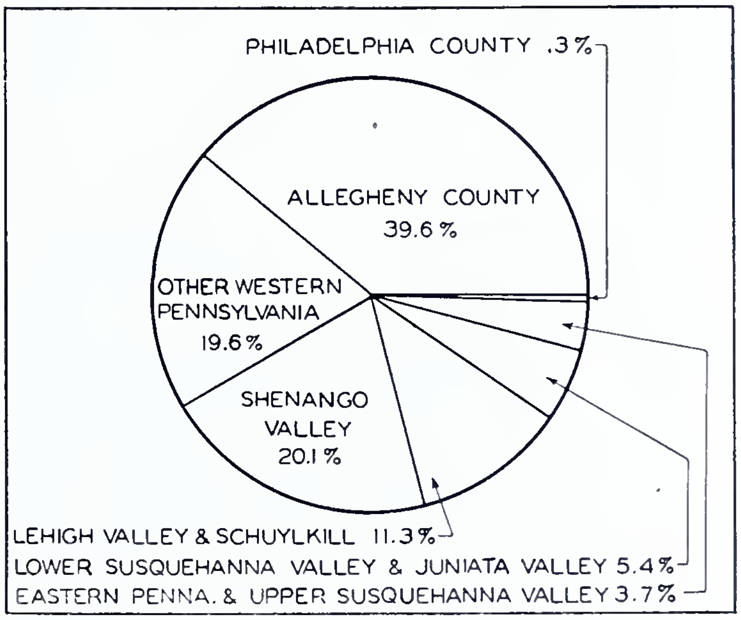

Fig. 96. Production of all kinds of finished rolled iron and steel in Pennsylvania by districts, 1931. (Data from Annual Statistical Report of the American Iron and Steel Institute, 1931.)

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[6] Data as to the relative importance of the two sections of the State as producers of steel ingots and castings are not available. If available, they would tell much the same story as the figures for pig iron and for finished, rolled iron and steel.

steel[7] than as a pig iron producer, as the above percentages indicate. This emphasis upon the finishing of steel rather than upon pig iron production is not surprising when it is remembered that ore is relatively difficult of access in eastern Pennsylvania, while there is an established industry in a good market situation. An established iron and steel industry under such conditions generally tends to specialize in the more advanced stages of steel manufacture rather than in pig iron production.

Causes of Localization.

Most of the iron and steel establishments of eastern Pennsylvania got their start when anthracite was the outstanding blast-furnace fuel, although some depended originally upon charcoal. Since coke took the place of anthracite, these centers have been at a marked disadvantage in obtaining fuel. They have, however, some distinct advantages. They are near Philadelphia and New York which, with adjacent cities, constitute a great market; they have been able to obtain some ore locally, chiefly from the Cornwall deposit in Pennsylvania, but also from small operations in New York and New Jersey; and their nearness to the Coast has made the importation of ore possible.

Present Distribution of Plants.

The present distribution of the iron and steel industry in eastern Pennsylvania is shown by Figures 91 to 96.[8] Smelting of iron ore and the manufacture of steel are concentrated in a relatively few centers, outstanding among them being Bethlehem in Northampton County. Steelton in Dauphin County is also important in these activities, while other plants are scattered over several of the southeastern counties. The distribution of rolling mills is less concentrated than the initial phases of the industry.

Companies Operating.

The Bethlehem Steel Company with plants at Bethlehem, Steelton, and Coatesville is the principal iron and steel company operating in eastern Pennsylvania. This company has a plant, also, at Johnstown, Pennsylvania (considered in this report as a part of western Pennsylvania), and plants at Lackawanna, New York, and Sparrow's Point, Maryland. In aggregate capacity of all plants the Bethlehem Steel Corporation is second only to the United States Steel Corporation, which is the dominant company in western Pennsylvania and in the entire United States.

Materials used in the Industry.

Iron Ore. — About 23,500,000 gross tons of iron ore (including beneficiated ore) were used in making pig iron in Pennsylvania in 1929, about 16,500,000 gross tons in 1930, and 7,984,648 gross tons in 1931. In the latter year, an average of 1.58 gross tons of ore were used in the State to make one ton of pig iron.

No exact data are available as to the tonnage of iron ore used by the iron and steel industry of eastern Pennsylvania, but estimates[9] suggest that between 3,000,000 and 3,500,000 gross tons (including beneficiated ore) were thus used in 1929, and about 1,000,000 tons less than this were used in 1930. It is further estimated that about 38 per cent of the iron ore used in eastern Pennsylvania in 1930 came from the Cornwall Mine in Pennsylvania, 28 per cent from mines in New Jersey and New York, 27 per cent from foreign countries, and 7 per cent from the Lake Superior region.

Past and present production of iron ore in Pennsylvania. Three types of iron ore have been mined in Pennsylvania: magnetic iron ore, brown iron ore, and red hematitic iron ore. The cessation of mining of brown iron ore and of red hematitic iron ore, and the limitation of the mining of magnetic iron ore to one mine, were not due to exhaustion of these ores, but simply to the fact that the deposits, though satisfactory when only low-grade ores were available, were not rich enough to be mined in competition with the high-grade Lake Superior ores which came on the market in the last half of the Nineteenth Century. The only iron ore being mined in Pennsylvania at the present time is a magnetic iron ore deposit at Cornwall.[10] The Cornwall deposit has a low iron content, averaging 35 to 40 per cent, but it is profitable to mine the ore because it can be beneficiated very cheaply. Recovery of some copper, a little gold and silver, and one or two other metals helps to make this mine profitable. It has had an average annual production for the ten years ending in 1930 of 900,000 tons of ore (Figure 97).

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[7] This probably applies, too, to the production of steel ingots and castings.

[8] The iron and steel districts of Pennsylvania as given in the annual statistical reports of the American Iron and Steel Institute are as follows:

Philadelphia County — Includes Philadelphia City and Philadelphia County.

Lehigh Valley — Includes Northampton, Lehigh, Carbon, and Bucks Counties.

Eastern Pennsylvania—Includes Delaware and all of Chester County except the northeastern part.

Schuylkill Valley—Includes Montgomery, Berks, Schuylkill, Northeastern part of Chester, and southeastern part of Lebanon County.

Upper Susquehanna Valley—Includes Lackawanna, Montour, Columbia, Northumberland, Union, Luzerne, Lycoming, and southeastern part of Perry County.

Lower Susquehanna Valley—Includes Cumberland, Franklin, York, Dauphin, Lancaster, and all of Lebanon County except the southeastern part.

Juniata Valley—Includes Centre, Bedford, Huntingdon, Mifflin, Blair, and all of Perry County except the southeastern part.

Allegheny County—Includes Allegheny County.

Shenango Valley—Includes Beaver, Lawrence, and Mercer Counties.

Other Western Pennsylvania—Includes all counties in Western Pennsylvania except Allegheny, Beaver, Lawrence, and Mercer Counties.

[9] Estimates based on data from the Lake Superior Iron Ore Association and on information in Mineral Resources of the United States, 1930—Part I.

Ore from New Jersey and New York. According to Davis[11] eastern Pennsylvania furnaces used, in 1930, "magnetites from the Beach Glenn, Cannon and Peters, Mt. Hope, Washington, Scrub Oaks, and Richard mines in New Jersey" and "magnetites from the New Bed, Old Bed, Harmony, No. 21, Chateaugay, and Forest of Dean mines in New York."

Importation. About the same amount of ore that entered eastern Pennsylvania from New Jersey and New York in 1930 was imported into the district from abroad through the ports of New York and Philadelphia. According to Davis[12] the ore imported for use in eastern Pennsylvania in 1930 came from Africa, Australia, Brazil, Chile, Newfoundland, Spain, and Sweden. Although the distances from these foreign deposits are great, water transportation is so cheap in comparison with rail haul that such importation is economically feasible.

Ore from the Lake Superior region. Iron ore from the Lake Superior region is of much less relative importance in eastern Pennsylvania than it is in the western part of the State. Practically all of the ore used in the West comes from the Lake Superior region, while only 7 per cent of the eastern Pennsylvania ore supply came from this source in 1930. The Lake Superior ore that is used is shipped by rail from Erie and Buffalo after its trip down the Lakes.

Future of iron ore mining. Students of the Lake Superior region believe that under normal conditions that region will soon pass its peak in iron ore production. For example, it is believed that the Mesabi, the most important of the Lake Superior deposits, will, under conditions of normal demand, reach its peak between the years 1945 and 1950. It is probable that the Lake Superior deposits will continue to be the country's chief source of iron ore for some years after this peak is passed, and that the region's decline in production will be delayed by beneficiation of ores not worth mining under present conditions. However, the location of new plants will be affected before the Mesabi peak is passed, as the reserves of the district will not be enough to insure retirement of capital investment. It is a live question even now for Chicago and vicinity. Increasing dependence upon some other source of supply is

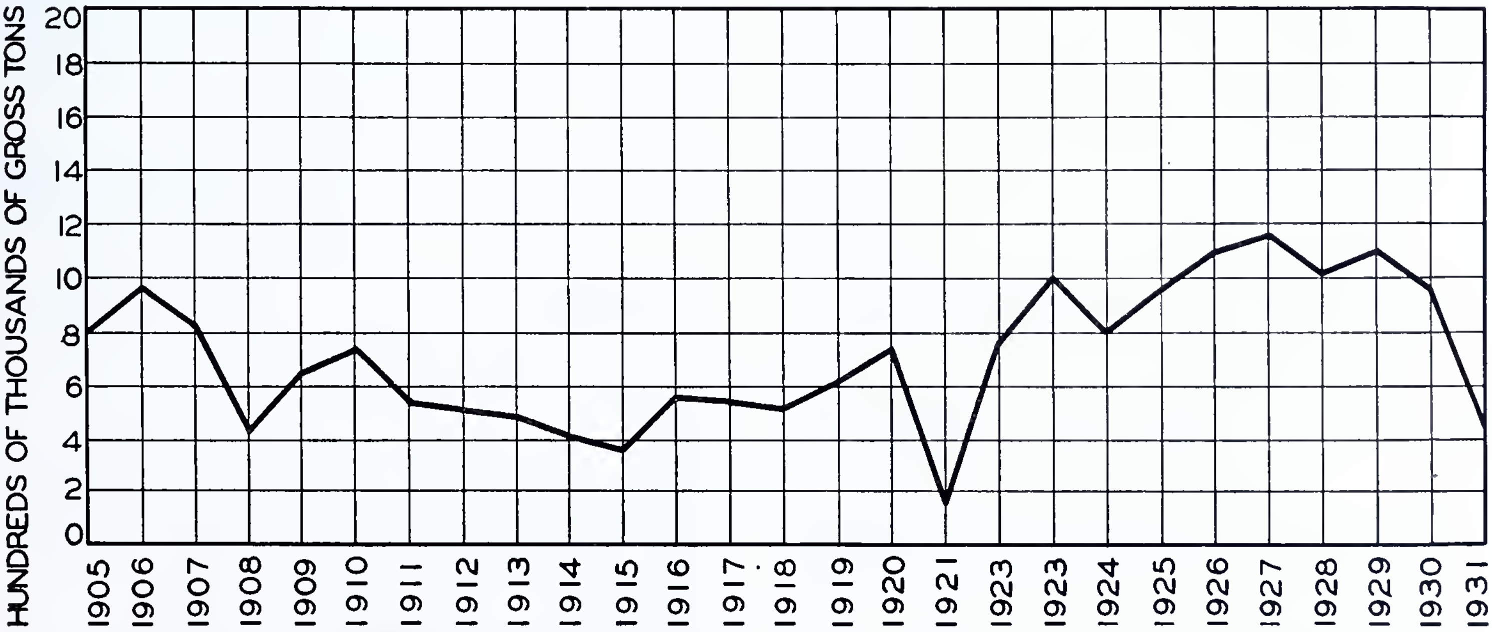

Fig. 97. Production of iron ore in Pennsylvania, 1905 to 1931. (Data from Mineral Resources of the United States.)

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[10] In addition, a very small amount of carbonate ore is mined in Carbon County and used in paint manufacture (See under Mineral Paints in the chapter on The Common Rock Industries of Pennsylvania.)

[11] Davis, Hubert W., Iron Ore, Pig Iron and Steel in 1930, Mineral Resources of the United States, 1930—Part I, p. 68.

[12] Davis, Hubert W., op. cit., p. 68.

inevitable, although the length of time until this dependence becomes serious will depend upon the future course of the curve of ore consumption, upon new developments in beneficiation, and upon other factors. When dependence upon other sources of supply becomes necessary, what will these sources be?

It has been suggested that with the decline of the Lake Superior region there may be a revival of iron ore mining in Pennsylvania, but this does not take into account the low grade of most of Pennsylvania's iron ores, nor does it take into account the large foreign deposits of high-grade ore which are now known. As production of the Lake Superior region declines, the deficiency will probably be made up very largely by increasing importation of ore from Brazil, or from other foreign sources. Although there is little likelihood of Pennsylvania becoming very important as a producer of iron ore, a possibility of increasing the State's production seems to exist in the possible discovery of new deposits of magnetic iron ores similar to those now being mined at Cornwall. It is believed that geophysical prospecting may reveal other deposits of this type.

Iron and Steel Scrap. — Within recent years there has been an increasing use of scrap steel and iron by steel plants, and, to a lesser extent, by blast furnaces. Ever since the open-hearth furnace was invented, scrap has formed part of its charge of raw materials, and the same is true of the electric furnace. Some idea of the increasing importance of scrap in steel manufacture may be gleaned from a comparison of the tonnage figures of total steel production with the tonnage output of pig iron (Figure 89). In 1911 total steel tonnage in the United States exceeded pig iron tonnage for the first time, and then by only about 25,000 gross tons; in 1929 this excess of steel over pig iron amounted to over 14,000,000 gross tons. The reuse of old steel and iron which this difference represents is very desirable from the standpoint of conservation. It is, moreover, a tendency which must be taken into consideration in estimating the probable time of exhaustion of iron ore deposits.

Limestone. — Fluxing stone is easy to obtain in the eastern Pennsylvania iron and steel district, as limestone forms most of the floor of the Great Valley in which Bethlehem and Steelton are located, and there are other areas of limestone farther southeast (see section on limestone in chapter on the Common Rock Industries). Some high-grade limestone has, however, been brought into the State by the Bethlehem Steel Company from McAfee, New Jersey, to supply its Bethlehem plant.

Fuel.—Eastern Pennsylvania is a considerable distance by rail from sources of coal. This is a serious handicap since coke is a necessity in blast furnace operation, and coal is needed, also, for the making of producer gas, the principal fuel of the steel industry.

Ferro-Alloys. — It has been mentioned earlier that small amounts of certain elements (chromium, cobalt, manganese, molybdenum, nickel, silicon, titanium, tungsten, or vanadium) known as the "ferro-alloys" may be added to steel in certain combinations to give it special properties. For example, the addition of manganese makes steel stronger and easier to forge; the addition of tungsten gives steel the property of holding its temper at a much higher heat than that at which most other steels become soft and worthless; nickel steel possesses great hardness, strength, and elasticity; and the presence of titanium makes a steel more malleable than is ordinarily the case. The ores of none of these ferro-alloys are produced in Pennsylvania at the present time. In fact most of them have to be imported into the United States.

Chromium. Nearly all of the chromite used in the United States is imported, the chief foreign sources in 1929 being Rhodesia, Cuba, Greece, British India, and New Caledonia. Low-grade deposits occur in several of our states, but the total United States production is very small. Some deposits of chromite occur in southeastern Pennsylvania, and they have at times been mined, but there is no production at present.

Cobalt. No cobalt is produced in the United States, that which is used in the country coming from Canada and from Belgian Congo.

Manganese has already been described as having important functions in the iron and steel industry in addition to its use as a ferro-alloy. Hence, it is used in greater quantities by the steel industry than any of the other ferro-alloys. Although produced to a small extent in Montana and several other states, more than 13 times as much manganese ore was imported into the United States in 1931 as was produced within the country. Russia and Brazil were the chief sources of imported manganese ore.

Molybdenum. The United States is by far the leading world producer of molybdenum, with Colorado and Utah the leading producing states.

Nickel is the most important of the alloy metals. Manganese is indispensable because of other functions in the steel industry, but it is not as important in making alloy steels as is nickel. A small amount of nickel is produced in the United States as a by-product of copper refining, but a very much larger amount is imported, chiefly from Canada.

Silicon as the oxide, silica, is a very common mineral in the rocks of the earth's crust. The United States has ample domestic supplies of silica.

Titanium is produced in Virginia, Florida, and California. Although this country has domestic supplies of titanium sufficient for all requirements, some of this metal is imported, chiefly from India and Senegal.

Tungsten is produced in several of our western states, but a much larger quantity has to be imported, the chief world sources being China and Burma.

Vanadium is produced in the United States in Colorado, Utah, and Arizona, but a much larger amount is imported from Peru.

Refractories. — Clay and nonclay refractories play an important role in the iron and steel industry. Their production in Pennsylvania has been discussed in Chapters IX and X.

Production Trends in Eastern Pennsylvania.

Pig iron production in eastern Pennsylvania has shown a fairly steady decline since 1923 (Figure 98), and eastern Pennsylvania's proportion of the nation's total pig iron production has been declining for an even longer period (Figure 99). Similarly, eastern Pennsylvania's proportion of the nation's total production of finished rolled iron and steel has been declining (Figure 100),

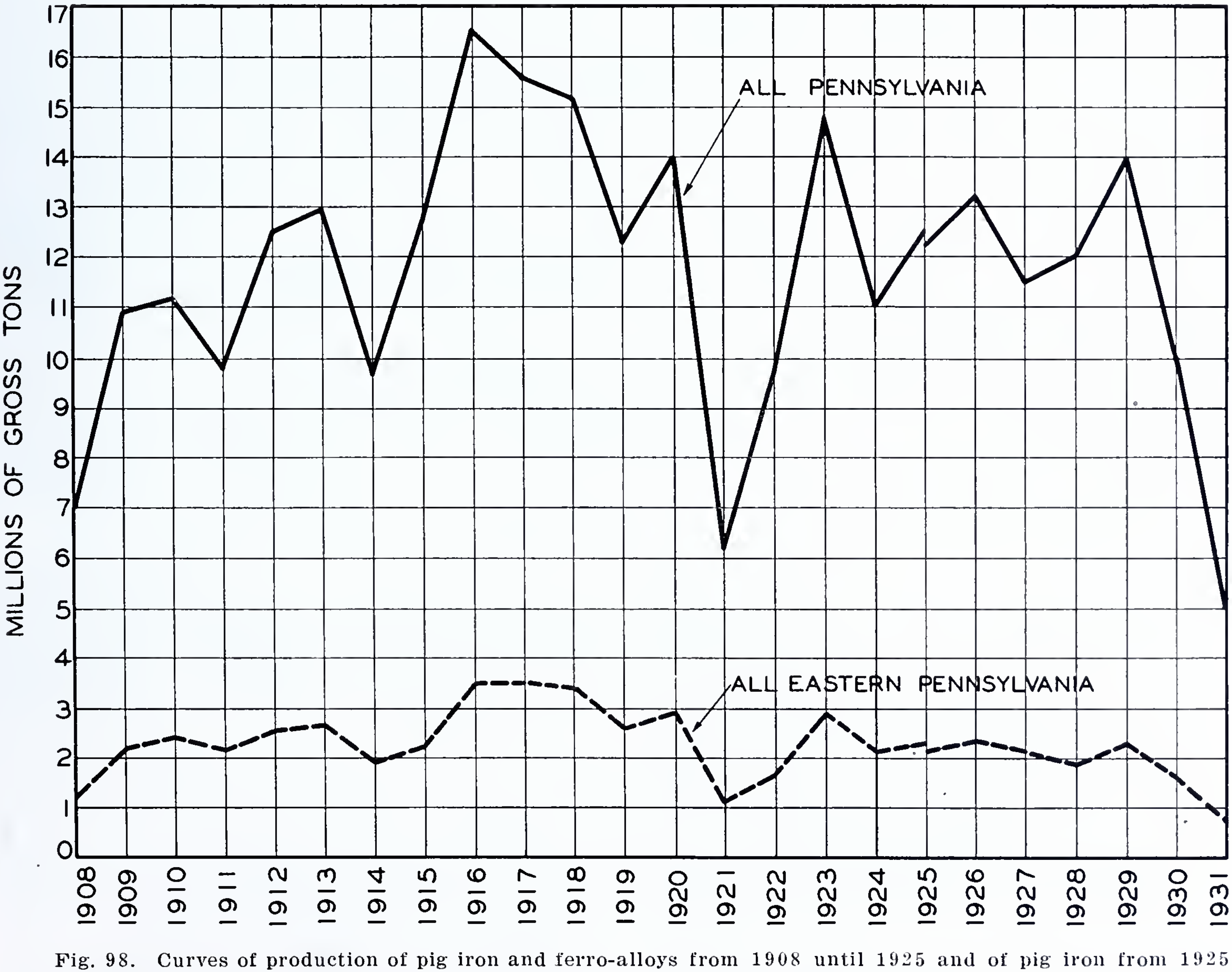

Fig. 98. Curves of production of pig iron and ferro-alloys from 1908 until 1925 and of pig iron from 1925 to later years—by eastern Pennsylvania and by Pennsylvania as a whole. See footnote on page 153 regarding ferro-alloys. (Data from annual statistical reports of American Iron and Steel Institute.)

and no doubt the same is true for the production of steel ingots and castings. For the production of all kinds of finished, rolled iron and steel, data for eastern Pennsylvania are available by sub-regions, the trends for each of these sub-regions being depicted in Figure 101.

Markets.

The Domestic Markets. — Eastern Pennsylvania is well situated to supply the important domestic market area which includes Philadelphia and other large cities in eastern Pennsylvania, the industrial cities of northern New Jersey, eastern New York, and New England. In fact, it is probably this good market situation that has made possible the continuance of the eastern Pennsylvania plants.

Foreign Markets. — The iron and steel plants of eastern Pennsylvania are also well situated for exporting. It is true, however, that this semi-coastal location is also a handicap because of the invasion of the coastal markets by foreign pig iron and steel. This invasion has gone on in spite of a protective tariff (see section on Foreign Trade in Iron and Steel).

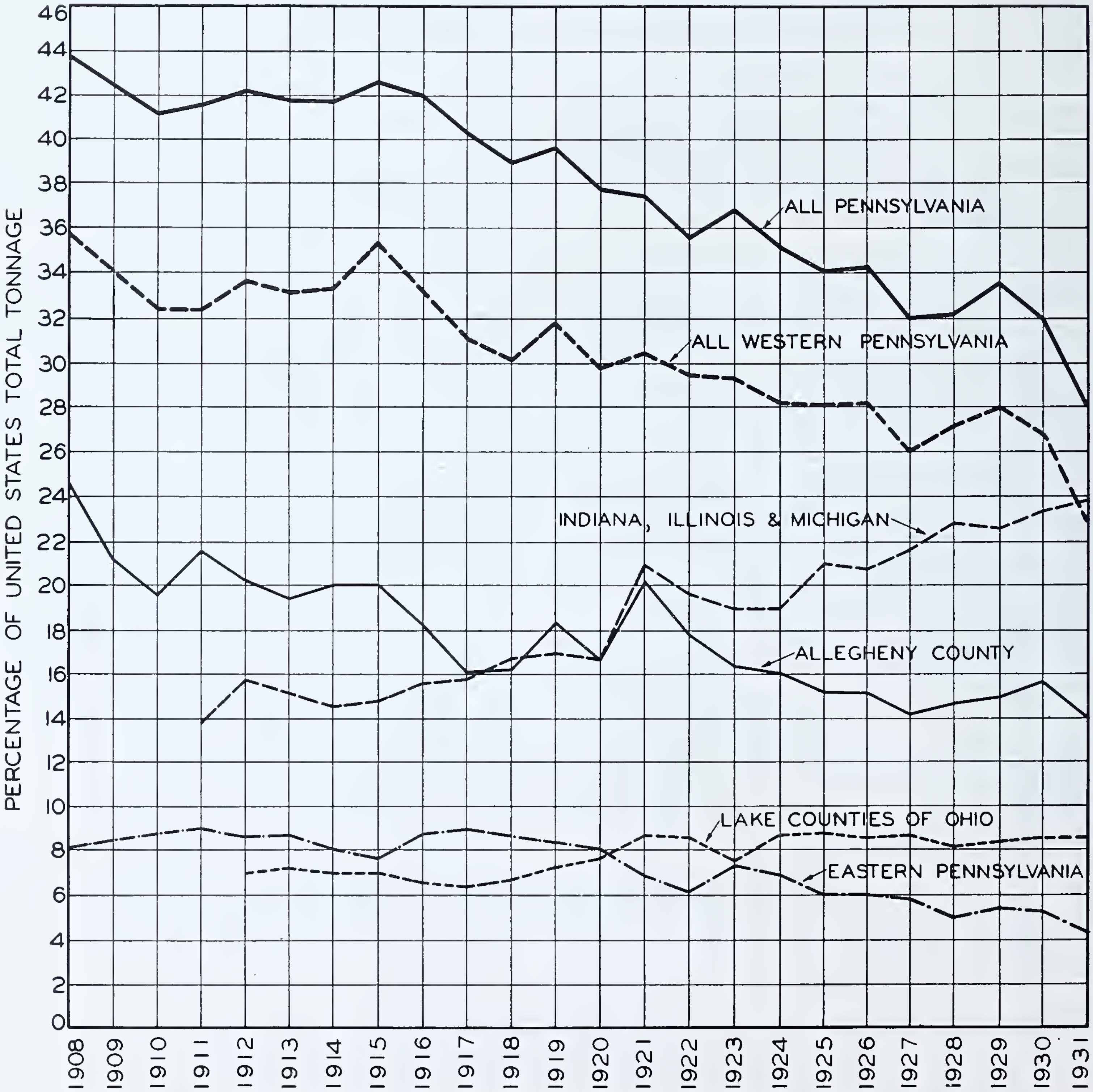

Fig. 99. Recent trends in relative importance of several Pennsylvania districts, of Pennsylvania as a whole, and of some competing areas as producers of pig iron and ferro-alloys. See footnote on page 153 regarding ferro-alloys. (Data from annual statistical reports of American Iron and Steel Institute.)

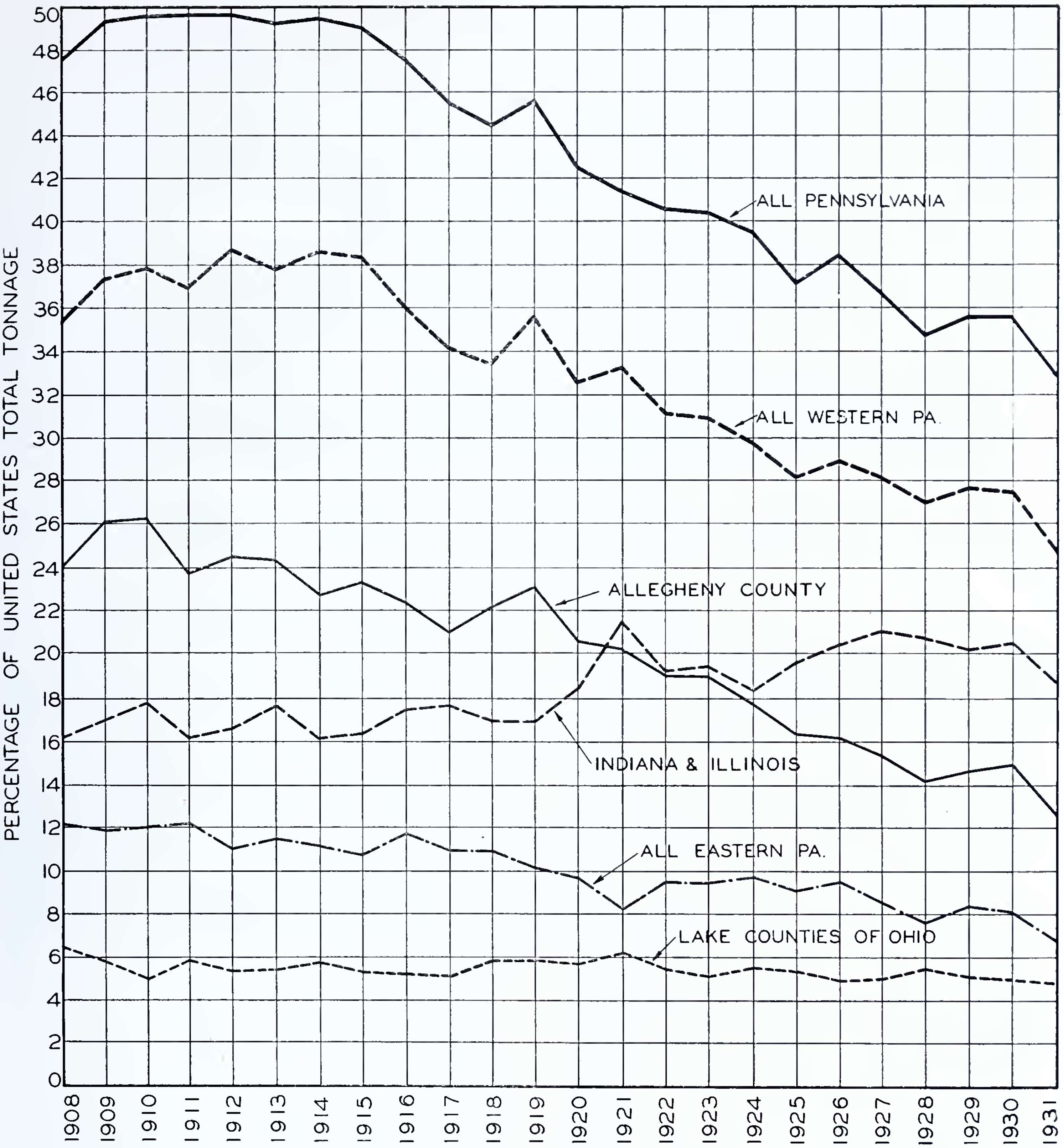

Fig. 100. Recent trends in relative importance of several Pennsylvania districts, of Pennsylvania as a whole, and of some competing areas as producers of all kinds of finished rolled iron and steel. (Data from annual statistical reports of American Iron and Steel Institute.)

Western Pennsylvania

The plants which give Pennsylvania its true claim to eminence as an iron and steel producer are those of western Pennsylvania, and paramount among these is the cluster at Pittsburgh. The western Pennsylvania plants represent a much greater aggregate capacity than those of the eastern part of the State.

Causes of Localization.

Much of the iron and steel industry of western Pennsylvania and eastern Ohio has spread from Pittsburgh. Why did Pittsburgh develop into an iron and steel center at an early date and maintain its position until the present?

Although an iron furnace was erected near Uniontown about 1790, using local iron ore and charcoal, the manufacture of iron in western Pennsylvania was hardly well begun before 1806.

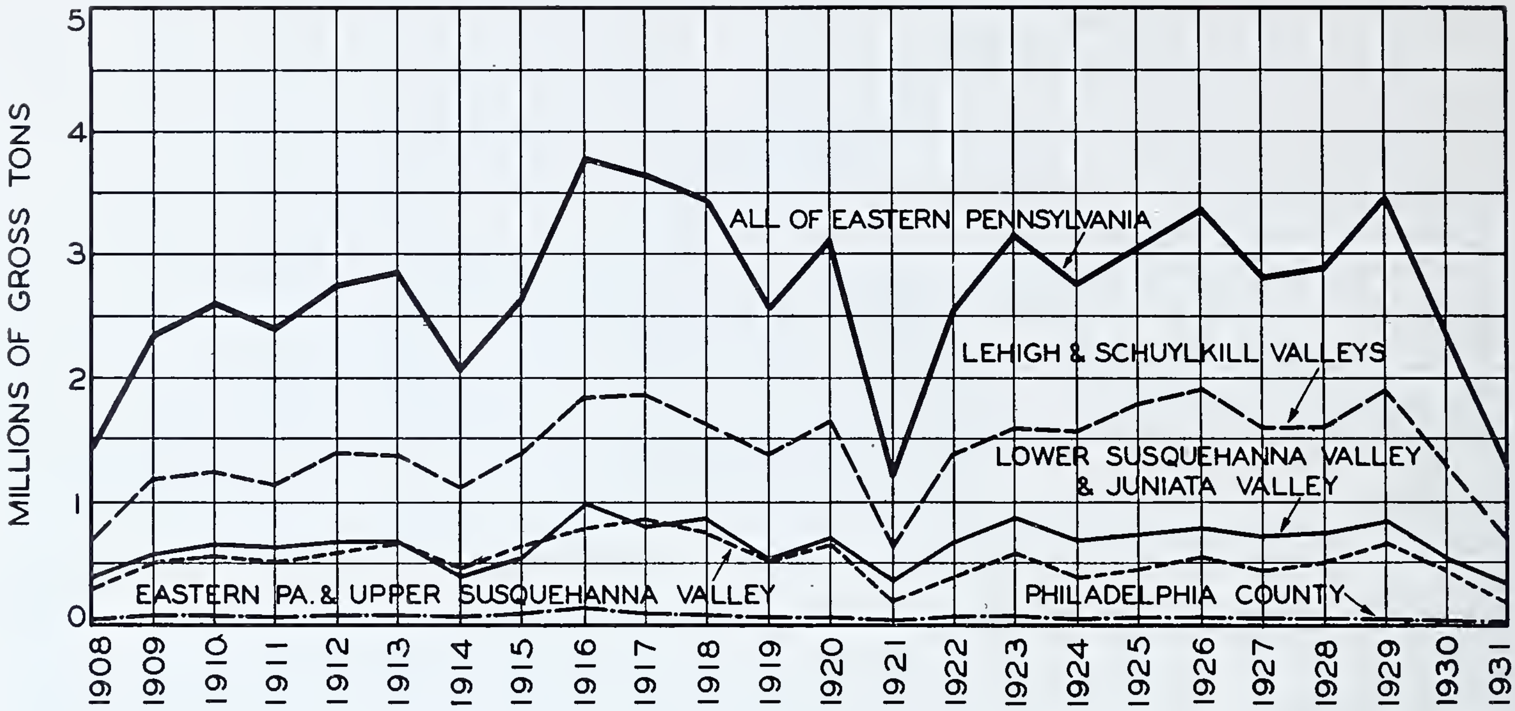

Fig. 101. Curves of production of all kinds of finished rolled iron and steel by the various districts in eastern Pennsylvania and by eastern Pennsylvania as a whole—from 1908 to 1931. (Data from annual statistical reports of American Iron and Steel Institute.)

The first rolling mills were built in 1812, and iron began to dominate the industrial life of the city after about 1825. The position of Pittsburgh, at the junction of the Monongahela and Allegheny rivers and at the head of the Ohio, gave it peculiar advantages for the development of the industry which has made it famous. In settling the Ohio Valley, Pittsburgh was the place of embarkation for the flatboat journey down the Ohio, so the settlers looked to Pittsburgh to fill their needs for manufactured goods. For a long time transportation from the East was so expensive that Pittsburgh and the surrounding region were called upon to produce most of the manufactured goods used in the Ohio Valley. Iron articles were most in demand. As pointed out earlier, it is only natural that an iron industry should have developed at such a point just as it did at Cincinnati farther down river. At first, however, an absence of local ore restricted the industry to the rolling mill phase.

When the rich ores of the Lake Superior region began to be brought down the Lakes, Pittsburgh had still a further advantage over the eastern plants. When it was found that Connellsville coke made the most satisfactory blast-furnace fuel, this advantage was still greater, as the coal used for making this coke was produced south of Pittsburgh and the coke could be brought to the city by way of the Monongahela. Naturally, the iron and steel industry could not have developed in the Lake Superior region, since the products made there would have been too far from market, and it would have been necessary to haul the fuel too long a distance. From our present point of view, the logical place for establishment of the industry seems to have been somewhere between the markets of the East and those of the Middle West. The southern Lake ports, particularly those on the south shore of Lake Erie, had the best situation; there Connellsville coke could meet iron ore from the Upper Lakes without reloading the ore after it was dumped from the lake steamers. Pittsburgh had a considerable industry, however, before the Lake Superior ores came into use; and the large amount of money invested in blast furnaces and steel mills that would have to be sacrificed if plants were moved, enabled, and still enables, Pittsburgh to hold its place as the greatest iron and steel center in America. From the industrial nucleus at the forks of the Ohio, city after city has grown up along the Allegheny and Monongahela rivers, along the Ohio, and even along Beaver River northward toward Lake Erie. In fact, several of the lake shore cities have developed as iron and steel centers. Thus, the present iron and steel industry stretches from Pittsburgh, where it was first established, to the Erie ports where it might logically have developed.

Johnstown possesses fewer present-day advantages for iron and steel manufacture than does Pittsburgh. Coal from farther west must be mixed with the local coal in making coke, ore must travel a longer distance in reaching this center than in reaching Pittsburgh, and markets are, on the whole, less accessible. However, since the present facilities for iron and steel manufacture at Johnstown represent a considerable investment, it is improbable that they will be abandoned for some years to come. The Johnstown industry received its start when that city was head of navigation on the western branch of the Pennsylvania Canal.

Distribution of Plants.

The distribution of iron and steel manufacturing in western Pennsylvania is shown by Figures 91 to 96. Pittsburgh and the towns just up the Monongahela and Allegheny rivers and down the Ohio; Johnstown; New Castle; and a group of towns in western Mercer County—these are the major centers of the industry in western Pennsylvania, although Butler, Vandergrift, Erie, and several other cities each have one or more phases of the industry.

Operating Companies.

The principal companies operating in extreme western Pennsylvania are the Carnegie Steel Company, a subsidiary of the United States Steel Corporation, and the Jones and Laughlin Steel Corporation. At Johnstown, the Bethlehem Steel Company is dominant, although there is also a castings plant which is a United States Steel subsidiary.

Sources of Materials used in the Industry.

Iron Ores and Scrap.—Western Pennsylvania has long depended upon Lake Superior ores. According to the Lake Superior Iron Ore Association, the Pittsburgh District[13] (including the Beaver County plants) received about 12,200,000 gross tons of ore from Lake Erie ports in 1930; the Valley district (including the New Castle and Mercer County plants in Pennsylvania and a somewhat larger area in Ohio with Youngstown as its center) received 5,900,000 gross tons; Johnstown received 1,400,000 gross tons; the Dubois District (Dubois and Punxsutawney) received 100,000 gross tons; and Erie received 200,000 gross tons for its own use in addition to what it received for reshipment.

The increasing use of scrap in the iron and steel industry was discussed on page 166.

Coal.—Good coking coal is particularly abundant in western Pennsylvania. Most of the coke has, in the past, been made in the Connellsville district of Pennsylvania and shipped down river to plants in and to the northwest of Pittsburgh. It has been pointed out earlier in this report that Greene County, because of its large reserves, seems destined to be the principal area of coking coal production in western Pennsylvania in the future; but this change should not affect the iron and steel industry, since most coke manufacture is now carried on in by-product ovens at the places where the coke and coke-oven gas are to be used.

Gas.—For a long time natural gas was the dominant fuel of the steel mills in western Pennsylvania, but the supply was eventually found to be inadequate. With the shift to by-product coking, a considerable amount of by-product gas became available at most of the iron and steel centers, but producer gas, manufactured by the consuming plants, is the common steel plant fuel.

Limestone. — The sources of fluxing stone for the western Pennsylvania industry have been discussed under limestone in the Common Rock Industries chapter.

Ferro-Alloys. — The various ferro-alloys used in the iron and steel industry of western Pennsylvania are, as in eastern Pennsylvania, made from ores brought in from other states or from outside the United States.

Refractories.—Western Pennsylvania is better equipped with refractories than eastern Pennsylvania, since fire clay occurs widely in the Coal Measures, the rock layers in which the coal occurs.

Pittsburgh—the Leading Iron and Steel Center of Western Pennsylvania.

Pittsburgh so completely epitomizes the iron and steel industry of western Pennsylvania that it is here made the subject of special discussion. Products of blast furnaces, steel plants, foundries, and machine shops make up one-half of the total value of all the city's manufactures. The products are, in many cases, "heavy" iron and steel goods, in which the amount of material rather than the amount of skill and labor largely determines the value. Such products are likely to be characteristic of an iron and steel producing region where conditions are, or have been, favorable for the assembling of necessary materials.

Transportation.—Both water and rail transportation are of great importance to Pittsburgh's iron and steel industry.

Water Transportation. Of paramount importance in making possible the present iron and steel industry of Pittsburgh and vicinity has been the availability of the Great Lakes. The Lakes make possible the transportation of Lake Superior ores to within 141 miles of Pittsburgh. If all-rail shipment were necessary, it is highly unlikely that Pittsburgh would occupy its present premier position as an iron and steel center.

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[13] Note that the districts described here are not the same as those delimited by the American Iron and Steel Institute and used in various graphs throughout this report (see footnote, p. 164.)

Of course Pittsburgh is not as advantageously located for getting this ore as are the Lake Erie cities or as South Chicago and Gary on the south shore of Lake Michigan. According to calculations of a few years ago it cost $1.23 more to lay down a ton of iron ore at Pittsburgh than at Chicago or Cleveland[14], but this disadvantage is offset by cheaper fuel at Pittsburgh.

Pittsburgh lies at the junction of the Monongahela and Allegheny rivers, and the Monongahela is America's most used river. Canalization has overcome the natural handicaps imposed by annual periods of flood and drought, and the Monongahela has been, for some time, exceedingly valuable to Pittsburgh as a means of obtaining cheap fuel from the coking coal fields to the south. The Allegheny is used to a lesser extent to bring in fuel. The Ohio serves the towns below Pittsburgh in a similar way, while both the Monongahela and the Ohio are used for the movement of some iron and steel.

A Pittsburgh to Lake Erie canal has been proposed to extend from Beaver on the Ohio River to Lake Erie at Indian Creek. While this would be an advantage to Pittsburgh in some respects, it might operate, too, to shift the industry to the south shore of Lake Erie through permitting cheap movement of coking coal to Lake Erie points by barge.

Rail Transportation. In spite of the great value of waterways to Pittsburgh's iron and steel industry, railroads are of much greater importance. On the railroads the ore moves from Lake Erie, and much of the coal for coking and the limestone used arrives by rail. Nine trunk lines serve Pittsburgh. The considerable relief of this region has restricted railroad courses largely to the valleys, and this has been somewhat of a limiting factor in railroad development since there is little room for location of new lines or expansion of yards.

Topography's Limitations Upon Growth of the Industry.—In addition to its effect upon the railroads, the lack of flat land in Pittsburgh and vicinity has been a direct limiting factor in the growth of the iron and steel industry. With flat land restricted to narrow ribbons of valley bottom, some companies have experienced great difficulty in obtaining sufficient land for the expansion of old plants or the erection of new. Several of the steel companies when they have wished to extend operations have been forced to move to some of Pittsburgh's satellite towns — Midland, Aliquippa, and others.

The Market For Pittsburgh's Iron and Steel.—As Pittsburgh's iron and steel industry has grown, so has the population of the city and of the country near it. A few years ago it was said that Pittsburgh lay within 450 miles of 60,000,000 people, or more than one-half of the nation's total population. The plants of Pittsburgh and vicinity are well-situated to supply an important part of the United States.

As a result of its central location with respect to a large market and the availability of raw iron and steel, Pittsburgh is the center of America's secondary iron and steel industries as well as of the primary phases. This means, of course, a large local market for Pittsburgh's primary iron and steel products.

Pittsburgh Plus. For many years Pittsburgh had a distinct advantage over other centers of the iron and steel industry because of the operation of the "Pittsburgh Plus" system. According to this system (used by the United States Steel Corporation) the prices quoted for products manufactured at, and shipped from, points outside of Pittsburgh were the regular F. O. B. Pittsburgh prices plus amounts equivalent to the railroad freight charges on such products if shipped from Pittsburgh. Under this system, which was eliminated in 1924, Pittsburgh was the absolute monarch of the steel industry for her market was the whole United States. The elimination of "Pittsburgh Plus" certainly would seem to give competing centers wider markets, and, theoretically, to give Chicago plants an advantage west of "a north and south line drawn substantially half way between Chicago and Pittsburgh."

Considerable tonnages of Pittsburgh steel are now sent by barge over the waters of the Ohio and Mississippi rivers, so Pittsburgh's actual market extends far beyond the theoretical line mentioned. Some of these products are reshipped from Mississippi River points to the Mid-Continent Oil Field, and shipment by barge as far as Kansas City has been visualized.

Advantages and Disadvantages of the Pittsburgh Iron and Steel Center.—A recent writer[15] has summed up the advantages and disadvantages of the Pittsburgh district as follows:

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[14] White, Langdon, The Iron and Steel Industry of the Pittsburgh District, Economic Geography, Vol. 4, 1928, p. 129.

[15] White, Langdon, op. cit., pp. 135-137.

“Pittsburgh rose to its position of prominence because, during the latter half of the nineteenth century, it had the most advantageous location in the country for steel manufacture.

“It has retained first place in this industry because (1) of its proximity to the world's best coking coal at Connellsville; (2) of its proximity to the lower lake ports of Ashtabula, Conneaut, Cleveland, and Fairport to which Lake Superior ores are cheaply transported by water in specially designed boats; (3) of its strategic location with reference to the great steel markets of the country; (4) of the momentum of an early start or the tendency of great plants involving a tremendous outlay of capital to remain where they became established; (5) of the “Pittsburgh Plus” (abolished in 1924); and (6) of the excellent transportation facilities, both rail and water.

“However, the frontier of steel making seems to be moving westward, because factors are at work which are disadvantageous to Pittsburgh. These are: (1) the lake ports such as Chicago, Gary, Cleveland, and Buffalo are taking an increasing proportion of the steel business, because they are more economical of transportation. In Pittsburgh some of the fuel and all the iron ore and limestone are shipped to the furnaces via rail. A lake port avoids one handling of ore and limestone by simply extending the journey of the coal to its by-product ovens; (2) Connellsville no longer has strangle hold on smelter fuel. So long as coke was made entirely in wasteful bee-hive ovens, the number of coking coals was limited, with Connellsville ranking first and Pocahontas second. But the by-product oven has largely displaced the bee-hive oven with the result that a wider variety of coals is now being successfully coked. In 1923 even in western Pennsylvania, the stronghold of the bee-hive industry, 29 per cent of the coke was made in retort ovens. This new process of coke-making has been one of the potent factors leading to the decentralization of the iron industry; (3) the “Pittsburgh Plus” was abolished by the Federal Trade Commission in 1924; (4) the nation's steel consumption is growing much more rapidly in the Middle West than in the older East, which means that Chicago has an advantage over Pittsburgh in consumptive capacity, and (5) there is a dearth of level land on the rivers for expansion

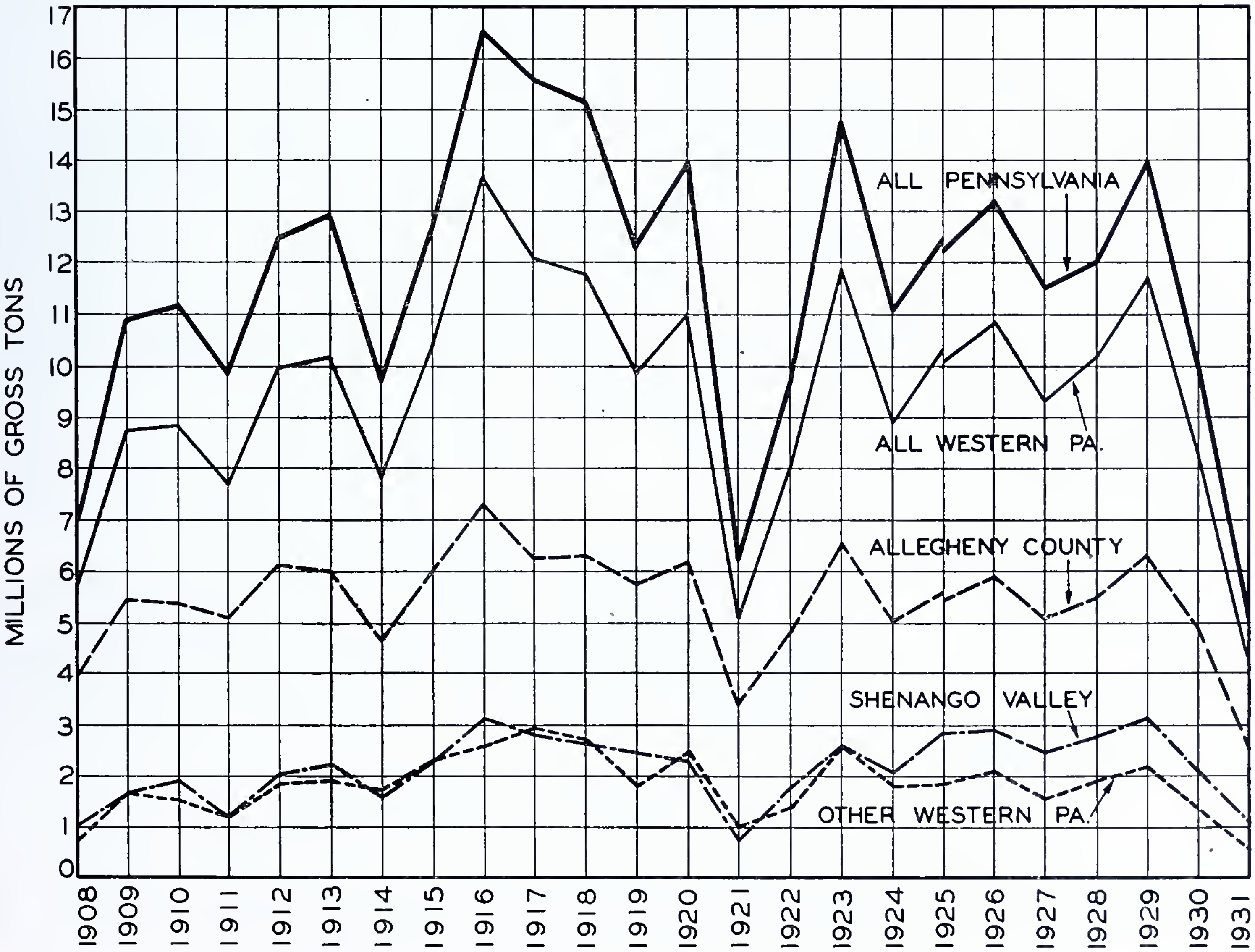

Fig. 102. Curves of production of pig iron and ferro-alloys from 1908 until 1925 and of pig iron 1925 and later years—by western Pennsylvania districts, by western Pennsylvania as a whole, and by the State. See footnote on page 153 regarding ferro-alloys. Data from annual statistical reports of American Iron and Steel Institute.)

either of established plants or for the erection of new ones. All the land suitable for iron and steel manufacture is occupied and the future development of the city must take place in the satellite suburbs and cities. This situation, of course, is in sharp contrast with that in the Chicago-Gary District, where the shore of Lake Michigan offered miles of cheap unoccupied land, which was acquired by the steel interests in immense tracts”.

Recent Trends in the Iron and Steel Industry of Western Pennsylvania.

Pig Iron. — Of the three divisions of western Pennsylvania as delimited by the American Iron and Steel Institute (see footnote p. 164), Allegheny County, with 49 per cent of the State's total pig iron production in 1931, was by far the leader; the Shenango Valley followed with 21 per cent; and the furnaces grouped as “Other Western Pennsylvania” produced 11 per cent of the State's total.

The production curves for the western Pennsylvania districts (Figure 102) bring out several facts of interest. It will be seen that western Pennsylvania as a whole has been steadily producing about 80 per cent of the State's total pig iron. The curve for western Pennsylvania, therefore, shows much the same trend as that of the State as a whole — rising to a 1916 peak; establishing a record “low” in 1921, a year of depression; oscillating without much general trend after 1923; and finally dropping in 1930 and 1931 in response to the period of depression then under way. Of the three subdivisions of western Pennsylvania, Shenango Valley, producing about one-fourth of the total pig iron of western Pennsylvania, was the only one to show a steadily rising tendency, although its curve, too, showed the effect of the depressions of 1921 and 1930 to 1931.

In its proportion of the total United States pig iron production western Pennsylvania has shown a persistent decline as also has Pennsylvania as a whole (Figure 99). These facts become particularly significant when it is noted that the curve showing the proportion of the total United States pig iron production accounted for by Indiana, Illinois, and Michigan has been ascending, while the curves for western Pennsylvania and for all of Pennsylvania have been descending. The curve for the Lake Counties of Ohio has shown a small net rise during the last twenty years. Separate data are not available for western New York (around Buffalo), but it is likely that that area, too, has been increasing somewhat in relative importance.

Steel Ingots and Castings.—Statistics of the production of steel ingots and castings for the several districts of Pennsylvania are not available

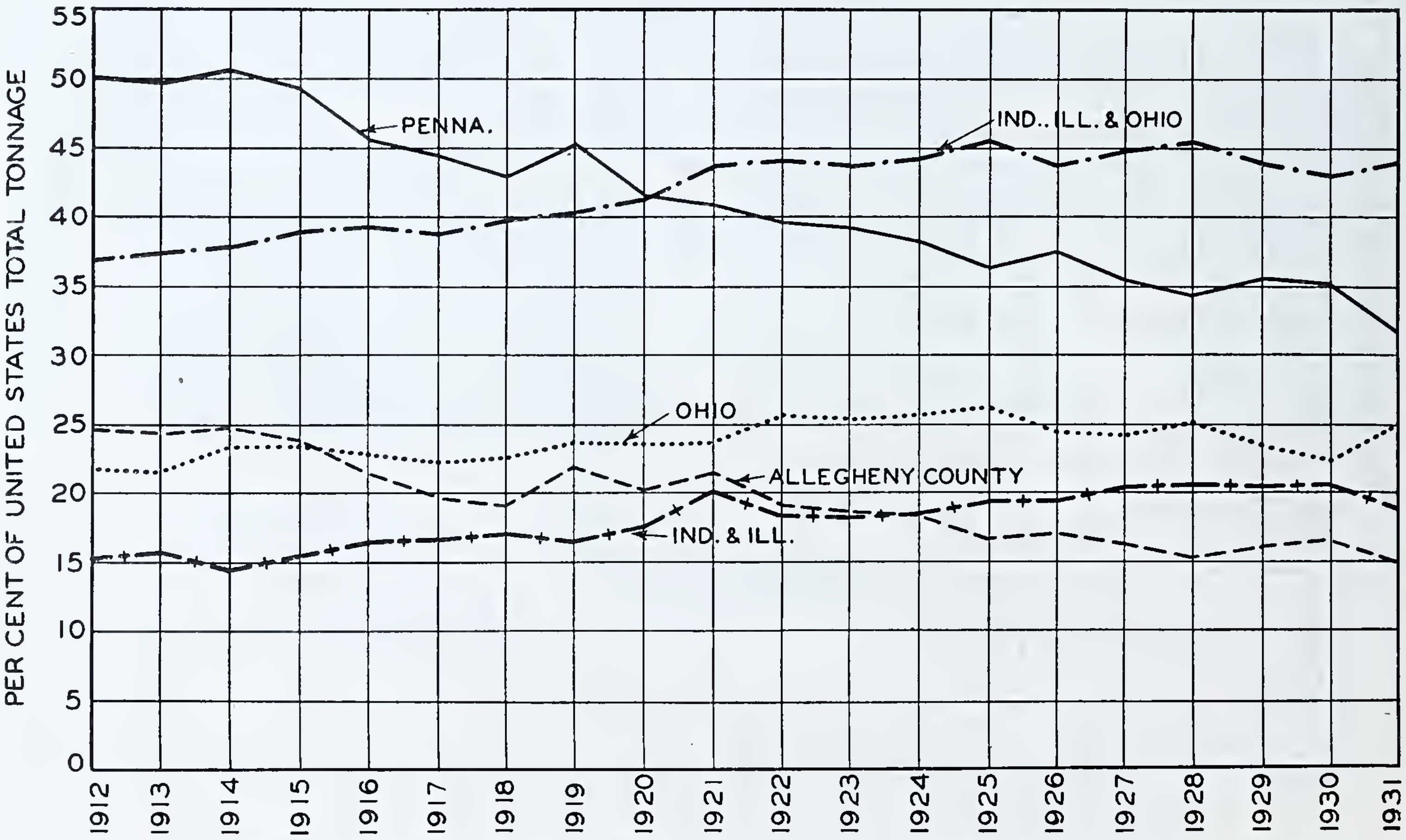

Fig. 103. Relative importance of Pennsylvania and of certain competing states in the production of all kinds of steel ingots and castings, 1912-1931. (Data from annual statistical reports of American Iron and Steel Institute.)

(except for Allegheny County, Figure 103), but production for the State as a whole shows the same general tendency as the pig iron production. While showing little consistent change in its total tonnage, Pennsylvania's proportion of the United States total declined from about 50 per cent in 1910 to 32 per cent in 1931. During the same period the percentage contributed by Illinois and Indiana together rose from 15 to 19.

Finished Rolled Iron and Steel. — Western Pennsylvania produced 79.3 per cent of all finished rolled iron and steel produced in the State in 1931 in contrast to 83.7 per cent of the pig iron (Figures 95 and 96). It follows that western Pennsylvania is of slightly less relative importance in the State in the production of finished rolled iron and steel than in blast furnace operations.[16] Allegheny County dominated Western Pennsylvania with 39.6 per cent of the State's total of finished rolled iron and steel; Shenango Valley accounted for 20.1 per cent; and Other Western Pennsylvania for 19.6 per cent.

The production curves for finished rolled iron and steel (Figure 104) are quite similar to those for pig iron, and bring out the same facts. Similarly, too, the curves showing percentages of the United States total (Figure 100) are much the same as those for pig iron.

General Conclusions From Trend Analysis.— It is apparent from the foregoing curves that there has been, during recent years, a steady decline in Pennsylvania's proportion of the United States total production of pig iron, of steel ingots and castings, and of finished rolled iron and steel. This is accounted for partly by the increasing importance of the Illinois-Indiana area and partly by development of the industry elsewhere.

Various causes have contributed to Pennsylvania's decline in relative importance as a steel producer. Prominent among such causes has been high freight rates to outstanding steel consuming centers farther west and northwest. Early in 1933 Pittsburgh steel men were demanding freight

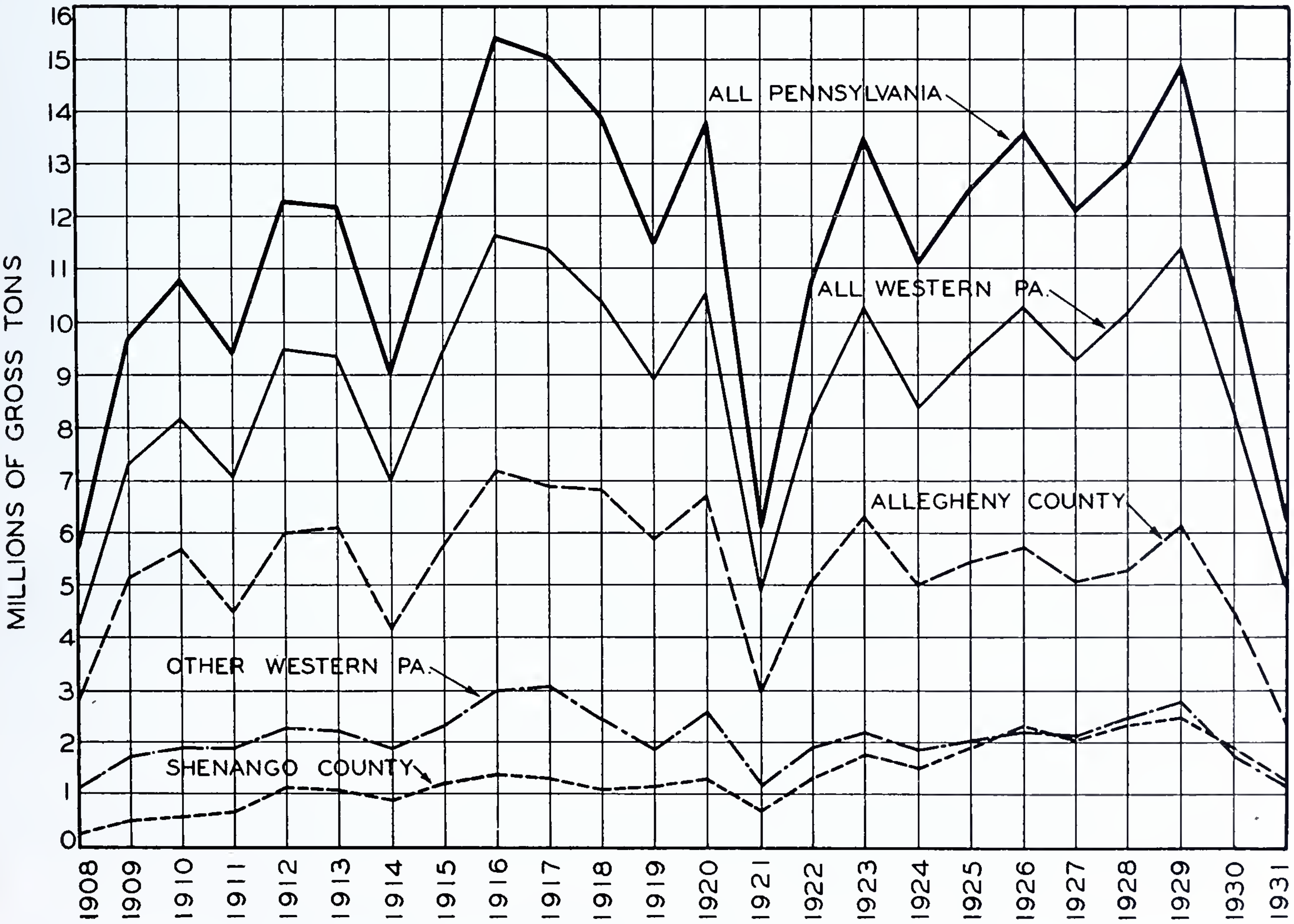

Fig. 104. Curves of production of all kinds of finished rolled iron and steel by western Pennsylvania districts, by western Pennsylvania as a whole, and by the State—from 1908 to 1931. (Data from annual statistical reports of American Iron and Steel Institute.)

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[16] It is probable, too, that western Pennsylvania is of less relative importance in the production of steel ingots and castings than in pig iron production.

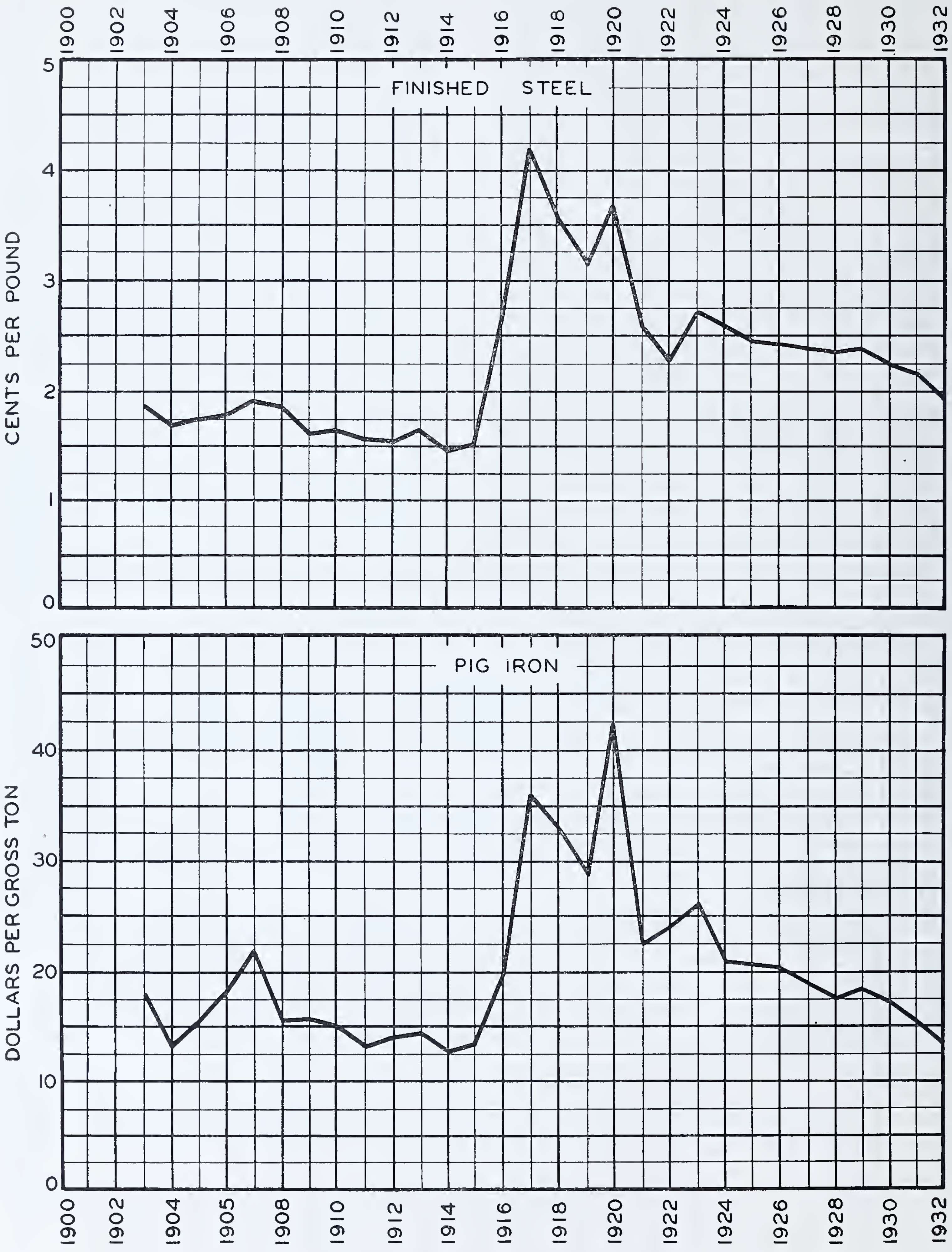

Fig. 105. Composite iron and steel prices for recent years as determined by the Iron Age. The steel index (quoted in cents per pound) is an average of Iron Age quotations on steel bars, beams, tank plates, plain wire, open-hearth rails, black pipe, and black sheets; the pig iron index (quoted in dollars per gross ton) is an average of Iron Age quotations for basic and foundry irons at the important iron markets.

rates to Detroit comparable with the water rates from the Chicago District. The statement was made that without some such adjustment many of the steel mills would have to relocate in Detroit.

Iron and Steel Prices

After declining until 1914, prices of finished steel and pig iron began a rise to the high levels which prevailed during and just after the War (Figure 105). Low prices followed in 1922. Then, after a slight recovery, a steady price decline set in and continued through 1932.

A rough correlation may be made between production curves (Figure 89) and price curves. In the years just before the War, production increase was accompanied by a steady price decline. During the War years, a large demand permitted great production and high prices at the same time. The post-War slump of 1921 affected both prices and production. Since 1921 increasing production has been accompanied by declining prices. Production reached a peak in 1929 and then began to decline, but prices declined during the entire period.

Foreign Trade In Iron and Steel

Iron Ore

The United States imported 1,465,613 gross tons of iron ore in 1931, chiefly from Chile, Cuba, Sweden, and North Africa. In the same year the country exported 435,665 gross tons of iron ore, the exports going almost entirely to Canada. The imports were equal to about 5 per cent of the country's total production; the exports amounted to 1.4 per cent of the United States production. There is no tariff on iron ore.

Iron and Steel

Imports.

Eighty-four thousand four hundred fifty-four gross tons of pig iron (equivalent to a little more than 5 per cent of the total United States pig iron production) were imported for consumption in the United States in 1931, and about 300,000 gross tons of steel (including rolled products) were imported the same year.

Protection From Foreign Iron and Steel.— The American iron and steel industry is protected by a tariff schedule which ordinarily has proved adequate. Naturally, the greatest competition from foreign iron and steel has been experienced in coastal sections—along the Atlantic, on the Gulf coast, and even on the Pacific coast. It follows that of the Pennsylvania producers those in the eastern part of the State have been, and are, the principal sufferers.

The chief source of imported pig iron is India and the chief source of foreign steel which enters the United States is Belgium

While, as a matter of fact, the total tonnage of imported iron and steel is small, the low prices being quoted on the imported products are said to be very disturbing to the American iron and steel trade. These low prices are explained in part by depreciation of the currency of countries from which part of these products come. The Hawley Bill is designed to counteract this difficulty by providing that an additional duty be levied if the value of the currency of any foreign country from which goods are received is 5 per cent or more below the standard value of such currency as proclaimed by the Secretary of the Treasury on October 1, 1932—the duty to be equal to the difference between standard value of the foreign currency and the depressed value.

The chief imports of steel, however, are from Belgium, France, and Germany, which have not departed from the gold standard. These countries are engaged in fierce competition for foreign markets initiated, in part, by Great Britain's recent erection of tariff barriers, thereby limiting what had formerly been an important market.

Exports.

The United States exported 6,719 gross tons of pig iron in 1931, .03 per cent of the total produced in the country. Canada and Japan received most of our exports.

Iron and steel exports other than pig iron totalled nearly 980,000 gross tons in 1931. As in the case of pig iron, Canada constituted our largest export market with Japan second.

The Ferro-alloys

Imports.

Ferro-alloys and ferro-alloy metals imported for consumption in the United States in 1931 had a value of $2,500,000. Though ferro-alloys are not used in very great quantities, they have a relatively high value per ton.

Tariff on Ferro-Alloys. — Tariffs have been levied on the ores of several of the ferro-alloy metals, e. g., on those of molybdenum, manganese, and tungsten, and on the ferro-alloys themselves; and there arise, periodically, demands for tariffs on others. The molybdenum tariff is not without reason, since this country has ample supplies of molybdenum ore, but the tariffs on manganese and tungsten illustrate uneconomic protection of domestic industries, since neither ore is present in sufficient quantity in the United States to justify such protection. It would seem much better to obtain ores of these metals from abroad, thereby conserving our own meager supplies for times of national emergency. As it is, even with a protective tariff, the United States produces only a small part of its manganese and tungsten requirements, the iron and steel industry must pay more for its materials, and the cost is passed on to the consumer. These uneconomic tariffs were levied in 1922; in 1930 the tariff on tungsten was increased, while that on manganese was broadened so as to include lower grades of ore than formerly.

Exports.

The exports of ferro-alloys are relatively unimportant, their total value in 1929 amounting to only $384,169.

The Future

Several influences have been at work tending to decentralize the iron and steel industry. When the industry turned from beehive to by-product coke it became possible for plants to develop some distance away from the source of coal. Abolition of the "Pittsburgh Plus" system promoted this decentralization still further so far as the western Pennsylvania industry is concerned. The curves showing the proportions of the United States total production of iron and steel products contributed by the various districts of Pennsylvania, by Pennsylvania as a whole, and by competing districts and states bring out only too clearly that some shift in the industry is going on. Pennsylvania is steadily declining in relative importance as a producer, while the Chicago-Gary district and some others are increasing in importance.

It must not be thought that decentralization is going on to such an extent that small widely scattered establishments are springing up. Instead, the small isolated furnaces are gradually being shut down. The decentralization consists, rather, of the growing importance of several important iron and steel centers at the expense of western Pennsylvania, the leader.

Exhaustion of the Lake Superior deposits, which produce over 85 per cent of the country's iron ore, is not to be expected in the immediate future. Improved concentrating technology making possible the use of a larger tonnage of Lake Superior ore than is now figured as part of the reserve, increased use of scrap iron and steel resulting in a smaller iron ore consumption—these and other influences may prolong the life of the Lake Superior district. When its tonnage does decline, the iron and steel industry of the United States will probably obtain more and more of its ore supply from abroad and from the great reserves of low-grade ore in southeastern United States. Increasing dependence on foreign ore is likely to result in a gradual migration of the iron and steel industry of the United States to the Atlantic coast —a movement in which the Bethlehem Steel Company with its Sparrow's Point, Maryland, plant may be considered a pioneer.

XV
OTHER METAL INDUSTRIES

Introduction

"Other metal industries" as here considered consist of the recovery of nonferrous metals (other than ferro-alloys) from their ores and from scrap (or old metal), and the refining and, in some cases, alloying of such metals. It is difficult to separate the earlier phases of many of these industries from the making of finished products, but from United States Census data the writer estimates that the primary phases[1] of the nonferrous metal industries of Pennsylvania had a total product value in 1929 of approximately $78,000,000 and a value added by manufacture of about $29,000,000.

Production of the Ores of Nonferrous Metals

No mines are operated in Pennsylvania primarily for the ores of any of the nonferrous metals at the present time, although some copper, gold, and silver are obtained as by-products in mining iron ore at Cornwall. Zinc was formerly mined extensively near Friedensville in Lehigh County, and some zinc deposits are known elsewhere in the State. Lead has been mined in central Pennsylvania and in Chester County. Some deposits of copper minerals occur in southeastern Pennsylvania, and mines have operated there for short periods, but these operations have met with little success.

Although mining of some of the ores of nonferrous metals may again be carried on in Pennsylvania, there is little prospect of the State becoming important as a producer of any of these ores.

Reducing, Refining, and Alloying

Only one nonferrous metal, zinc, is separated from its ores or concentrates in Pennsylvania, but zinc and several other metals are obtained by reducing and refining scrap or waste material. The zinc industry is the outstanding nonferrous metal industry of Pennsylvania.

The Primary[2] Zinc Industry

Uses of Zinc.

Zinc, in its various forms, has a great variety of uses. Slab zinc, pigments, zinc dust, and salts result from the treatment of ore concentrates or of old metal containing zinc.

Slab Zinc. — Slab zinc is the major product of zinc smelting. The three chief uses of slab zinc are in the manufacture of zinc-coated (galvanized) products, in brass making, and in the manufacture of sheet zinc. About 44 per cent of the total amount of slab zinc consumed in the United States in 1931 was used for zinc coating, 26 per cent in the manufacture of brass, and the remainder in the making of rolled or sheet zinc and various other products.

Other Uses of Zinc. — In addition to the making of slab zinc a large amount of zinc, probably more than goes into brass, is used in pigments; and zinc, in one form or another, is used in rubber manufacture, in various chemicals and medicines, in dye manufacture, for precipitating gold in the cyanide process, and for a great variety of other purposes.

The Present Zinc Industry in the United States.

The United States is well supplied with zinc ore, some sixteen states reporting mine production in 1931. Of the total zinc content of mined ore about 29 per cent came from the Tri-State district (Kansas, Missouri, Oklahoma), 19 per cent from northern New Jersey, 16 per cent from Montana, and the remaining 36 per cent from other western states, from Tennessee and Virginia, and from Wisconsin and Illinois.

The ore thus produced was made into slab zinc in ten states, the first four — Montana, Illinois, Oklahoma, and Pennsylvania—producing 80 per cent of the total. Pennsylvania was second among the states with 22 per cent of the United States total. All of the Montana production and a very small percentage of that from Illinois was electrolytic zinc, while the remainder of the zinc produced was made by distillation.

Recovery of Zinc from its Ores in Pennsylvania.

The smelting and refining of zinc from ores or concentrates had a product value of $34,843,205 in Pennsylvania in 1929 and a value added by manufacture of $17,845,327. Three thousand eight hundred and forty-five persons were employed by the industry in the State.

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[1] "Primary phases" as the term is here used, includes reducing, refining, and alloying as distinguished from the manufacture of finished products from the metals or alloys produced.

[2] "Primary" is here used in referring to the recovery of metal from its ores or concentrates. In this sense it is contrasted with "secondary" metal which is metal recovered from scrap or waste material.

Location of the State's Industry. — There are four plants in Pennsylvania engaged primarily in smelting and refining zinc from ore or concentrates, although only three of these plants were in operation in 1931. One plant is in the east, at Palmerton; the other three are in western Pennsylvania — two in Washington County (one each at Donora and Langeloth), and one in Beaver County near Monaca.

Development of the Industry in Pennsylvania —In 1845 zinc ore was discovered at Friedensville near Bethlehem, Pennsylvania, and in 1853 mining on an extensive scale was begun. This was the beginning of Pennsylvania's zinc industry, though it was not the beginning of the industry in the United States.

The company which began mining operations at Friedensville smelted most of its ore at South Bethlehem. After a varied career the Friedensville mines and the Bethlehem plant passed into the hands of the New Jersey Zinc Company, the actual consolidation occurring in 1897. The eastern Pennsylvania mines, which had been shut down since 1890, were not re-opened, but have simply been held in reserve. The new company scrapped its old plants at Jersey City, Newark, and Bethlehem after building, in the years 1899 to 1901, its great plant at Palmerton, Pennsylvania.

The zinc industry of western Pennsylvania was much later in development. The American Metal Company's plant at Langeloth was built about 1913; the Donora plant of the American Steel and Wire Company in 1915; and the plant of the St. Joseph Lead Company near Monaca was begun in 1930.

Localization of the Industry.—At first thought it seems peculiar that Pennsylvania with no zinc ore production should be an important producer of primary distilled zinc. The eastern Pennsylvania plant at Palmerton may be explained as a descendant of the early zinc operations in northern New Jersey and Pennsylvania, although it gets most of its ore at the present time from northern New Jersey and none from Pennsylvania. The location of the western Pennsylvania plants seems less logical, since these plants are far from their principal source of ore—the Tri-State region. Zinc ore is, however, concentrated before shipping, which lessens the freight burden. Moreover, west-

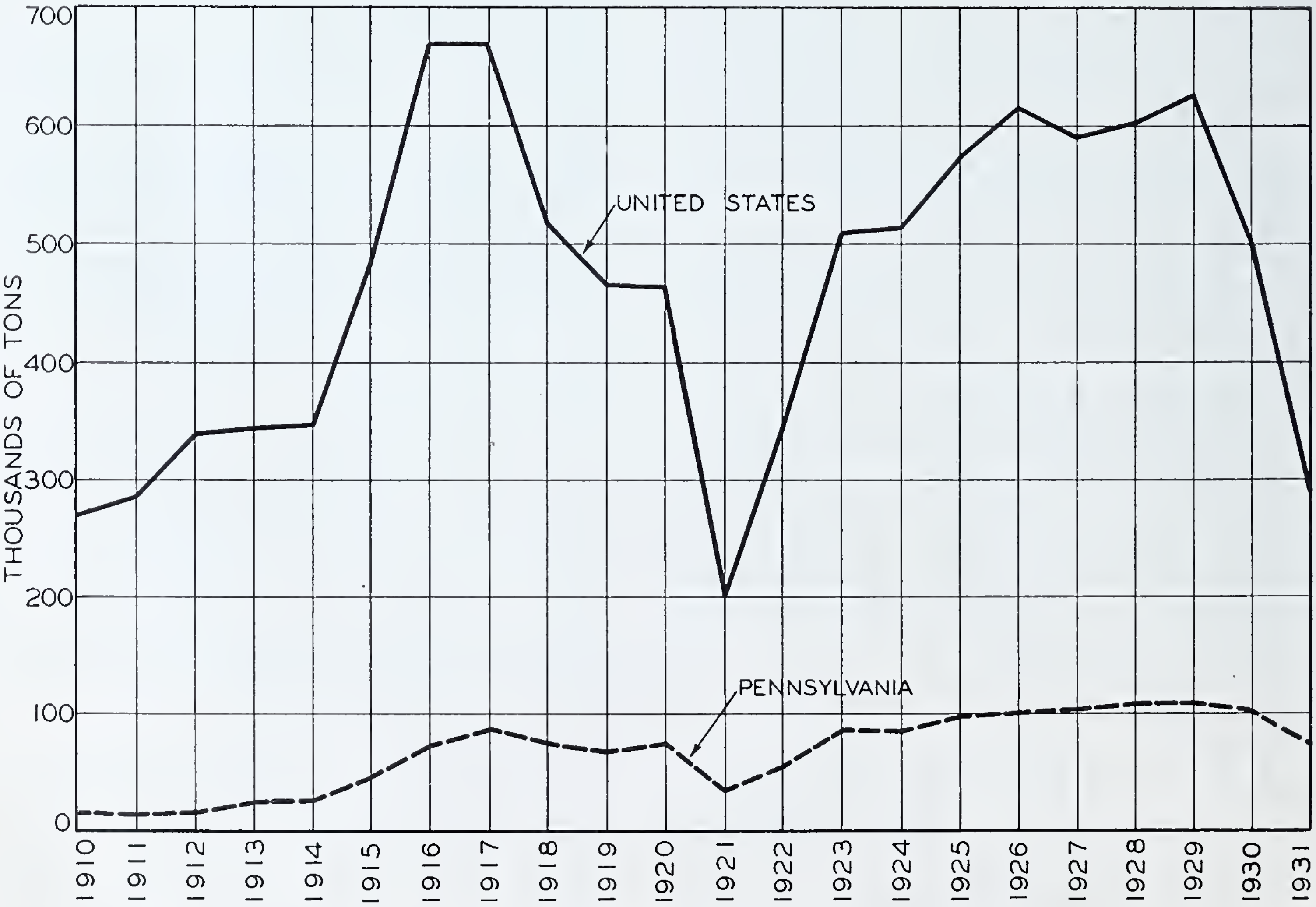

Fig. 106. Production of primary zinc by the United States and by Pennsylvania, 1910 to 1931. (Data from volumes of The Mineral Industry.)

ern Pennsylvania has coal for the making of producer gas which is used in the smelting operations, and the region is highly industrial, and, hence, is a good market for the two outstanding products of the industry—zinc, much of which is used to coat (galvanize) iron; and sulphuric acid, which is produced in even greater bulk than metallic zinc.

Organization of the Industry.—The only big corporation engaged primarily in the zinc industry is the New Jersey Zinc Company which operates the Palmerton plant. The American Metal Company which owns the Langeloth plant is a general metallurgical concern more interested in copper and lead than in zinc; the American Steel and Wire Company which operates at Donora, Pennsylvania, is a subsidiary of the United States Steel Corporation; the St. Joseph Lead Company which in 1930, was building a plant near Monaca, Pennsylvania, is, as its name suggests, primarily interested in lead. This subordination of the zinc industry to other enterprises is thought to have operated to the disadvantage of the industry, since it has tended to prevent broad economic cooperation.

The Trend in Primary Zinc Production.— During the twenty-year period ending in 1929 the production of primary zinc in the United States showed a net increase of about 135 per cent (Figure 106). The steady average rise was temporarily interrupted by a peak in War years and by a marked slump in 1921, a year of depression. In 1930 and 1931 the production had again fallen off markedly.

Pennsylvania's production showed a fairly steady increase during the 1910-1929 period, although it declined a few thousand tons in 1930 and more in 1931, while the State's percentage of the United States total tonnage increased from 6.1 per cent in 1910 to 17.3 per cent in 1929 and to 22 per cent in 1931. The increased relative importance of Pennsylvania in the depression years, suggests a steadier market for the zinc plants of Pennsylvania than for those of the Middle West and West.

Future of Pennsylvania's Industry. — It has been pointed out that Pennsylvania has risen in relative importance in the zinc industry. Addition of the St. Joseph Lead Company plant near Monaca should still further increase the State's relative importance as a zinc producer.

Overdevelopment and overproduction have hampered the zinc industry. At recent meetings of the American Zinc Institute the keynote has been broadening of the market for zinc through research for new uses.

The Production of Secondary Metals

Secondary Zinc.

Secondary zinc, or zinc recovered from old metal containing zinc, was equivalent to 35 per cent of the nation's total primary zinc output in 1931. This percentage is not likely to become much larger, since a large proportion of the zinc consumed is for dissipative uses such as zinc coatings, zinc dust, pigments, and salts which yield little secondary metal. It is estimated that less than 35 per cent of all the zinc mined each year is available for secondary usage.

About half of the secondary zinc recovery is done at plants such as the ones already mentioned which treat mainly ore. The remainder is recovered at retort smelters which use large graphite retorts. Of this latter character are the plants of the General Smelting Company and the Superior Zinc Corporation, both of Philadelphia, while other retort plants occur in New York, New Jersey, Alabama, and West Virginia.

Other Secondary Metals.

There are a number of plants in the State engaged in making brass and bronze and other nonferrous alloys from scrap; or in some other type of recovery of metals from waste materials. In many cases these plants make finished products from the metal recovered and to this extent their activities are outside the scope of this report. Because of the difficulty of allocating these industries and of separating the processing from the later manufacturing phases, they are not discussed in detail here.

The Value of Secondary Metals.

The writer estimates on the basis of available United States Census data that the total value of products of the earlier or processing phases of the State's secondary metal industries was about $43,000,000 in 1929, and the value added by manufacture, about $11,000,000.

XVI

THE FUTURE OF PENNSYLVANIA'S MINERAL INDUSTRIES

In the detailed discussion of the various mineral industries in preceding pages emphasis has been placed in turn upon problems peculiar to each industry. It must be borne in mind, however, that these industries have much in common; and it is as a group that the industries are considered in this final chapter.

Fundamental Problems

Certain general problems have been constantly recurring in the various chapters of this book. They are of concern to all of the people engaged in mineral industries, but not to these people only. Since Pennsylvania is primarily a mineral industries state, they are of importance to every other citizen of the State as well.

Freight Rates

One problem of vital interest is the obtaining of equitable freight rates.[1] Most products of the mineral industries are marketed some distance from their places of production, and in many cases transportation plays a large part in ultimate cost. Discriminatory or otherwise unfair freight rates may impose, locally, an insurmountable handicap upon certain industries. Each industry should undertake as part of its research program a study of rates as they affect that industry.

Taxation

Another fundamental problem which faces the mineral industries is that of taxation. While the taxation of mineral industries furnishes an important and necessary source of revenue for government operation, it is charged that some of the industries bear too large a tax burden. In some instances, notably in the case of anthracite, high taxes have so increased the price of the ultimate product that inroads of substitutes have been encouraged to the detriment of the industry.

Probably the most grievous and general of the tax problems which beset the mineral industries is that of taxation of reserves, i. e., of minerals in the ground. Owners of mineral lands pay taxes on these as mineral properties, although the deposits may be lying in store for the future, entirely undeveloped. Such a system of taxation is anti-conservational, since it encourages development in a period when overproduction is rampant. A deferred tax plan has been suggested whereby a tax on surface valuation only is paid until actual production commences; then the deferred taxes are collected.

This complicated subject of mineral land taxation in Pennsylvania has recently been investigated by a "Mineral and Forest Land Taxation Commission". The report of this Commission to the General Assembly, Session of 1933, discusses in much more detail than is possible here the problems of mineral land taxation and the remedies which have been proposed.

Tariffs

There are few if any of the mineral industries which are not protected to some extent by a tariff, or which have not clamored for such protection. In most cases these tariffs may be justified on the grounds that they strengthen industries which are of fundamental importance, but carried to excess they impose an unfair burden on the consumer through high prices.

Sometimes a tariff will benefit some branches of an industry but do actual harm to others. Thus, the tariff on foreign crude oil was favored by domestic crude producers and by refineries which used only domestic crude; it was opposed by Atlantic Coast refineries which depend in large part upon imported crude. Again, tariffs on mineral raw materials are sometimes distinctly anti-conservational in their effects, those which have been placed on certain of the ferro-alloys being of this character. There is a tariff on manganese, for example, a metal which is essential to the iron and steel industry, but of which the United States has inadequate deposits. Imposition of a tariff has stimulated the development of these inferior deposits, but even when thus subsidized the domestic supplies of manganese have proved entirely insufficient and importation has continued. The chief results of the tariff have been high costs to the consumers and the exhaustion of low-grade domestic deposits which might better have been kept for times of national emergency. Since fourteen pounds of manganese are required for each ton of steel made, it is clear that a shortage of manganese in time of war would be critical.

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[1] See Soft Coal Bulletin No. 2, Greater Pennsylvania Council (1933).

Overproduction

In almost every one of the mineral industries, either extractive or processing, overproduction is a serious matter. It is so in the bituminous coal industry, in the anthracite industry, in the petroleum industry, and in the iron and steel industry, as well as in many others. The curve of production has been rising more rapidly than the curve of demand. How to retard production to the point where such production is profitable is a major problem. The efforts that now go toward increasing production might better be spent in standardizing the quality of products, in developing new products, and in developing new uses for existing products.

Conservation

Conservation is another of the problems regarding the mineral industries which face the people of the United States and of Pennsylvania. As the term is properly used, it refers to the preservation of mineral resources for the future, not through deprivation of people living today, but through carefully guarding against waste and through complete and efficient utilization of the minerals which are consumed. Alarmists have at times thought that the nation's mineral resources were much more nearly exhausted than is actually the case. Such reports were, for example, circulated regarding petroleum some years ago, but since then new discoveries have indicated that the nation's reserves of this mineral fuel are still great. Again, as various mineral resources near exhaustion, scientific progress tends to correct the situation by the development of means of utilizing low-grade deposits, by the discovery of substitutes, and in other ways. While, because of these facts, few people feel that we should stint ourselves so that those of future generations may have adequate mineral supplies, yet it is highly important that mineral resources should not be wasted and that utilization be efficient and complete. Minerals, unlike the products of the farm and the forest, are irreplaceable, and when our present supplies are used up there will be no more forthcoming.

General Trends

Attention was called in an early chapter to the rapid increase in mineral use in the World, and, particularly, in the United States, within the past several decades. This increase has been markedly less within the last year or two, and there are indications that the rate of increase will, even after the present depression is over, continue less than it formerly was. A still more alarming fact is that Pennsylvania's proportion of the United States total for many of the mineral industries is decreasing. A comparison of the 1919 and 1929 figures for value created by the principal mining and mineral processing industries represented in the State is illuminating in this regard (Figure 107). In the period referred to the value created by this group of industries in Pennsylvania declined about 5 per cent; the value created by this same group of industries in the United States as a whole increased about 26 per cent. The State is apparently suffering more of a decline in its mineral industries than is the nation as a whole, and this decline is going on in almost every one of the State's mineral industries.

Needs of the Mineral Industries

Since Pennsylvania depends primarily upon her her mineral industries, the fact that she is losing ground in her relative importance in these industries in the United States is a serious matter. Without her mineral industries Pennsylvania would be but a minor state, since there would be little reason for the development of other manufacturing industries, and since much of the State's area is unsuited both by topography and by soil for the development of high-grade agriculture. It seems clear, therefore, that attention should be focussed on the mineral industries, and that they should be accorded the treatment which their importance to the State justifies.

The Commonwealth is paying the penalty of pioneering. With many of her resources the higher quality and more easily recoverable deposits are being depleted. In order to maintain supremacy she must make up in inventive genius and intelligence of operation what she is lacking in natural advantage. Research is, therefore, imperative.

Fortunately, there are favorable indications on the horizon. The research work of the Anthracite Institute and of the Central Pennsylvania Coal Producers' Association along both fundamental and applied lines are shining examples. Coal producers are beginning to study their needs and to use laboratory investigation as a method of ob-

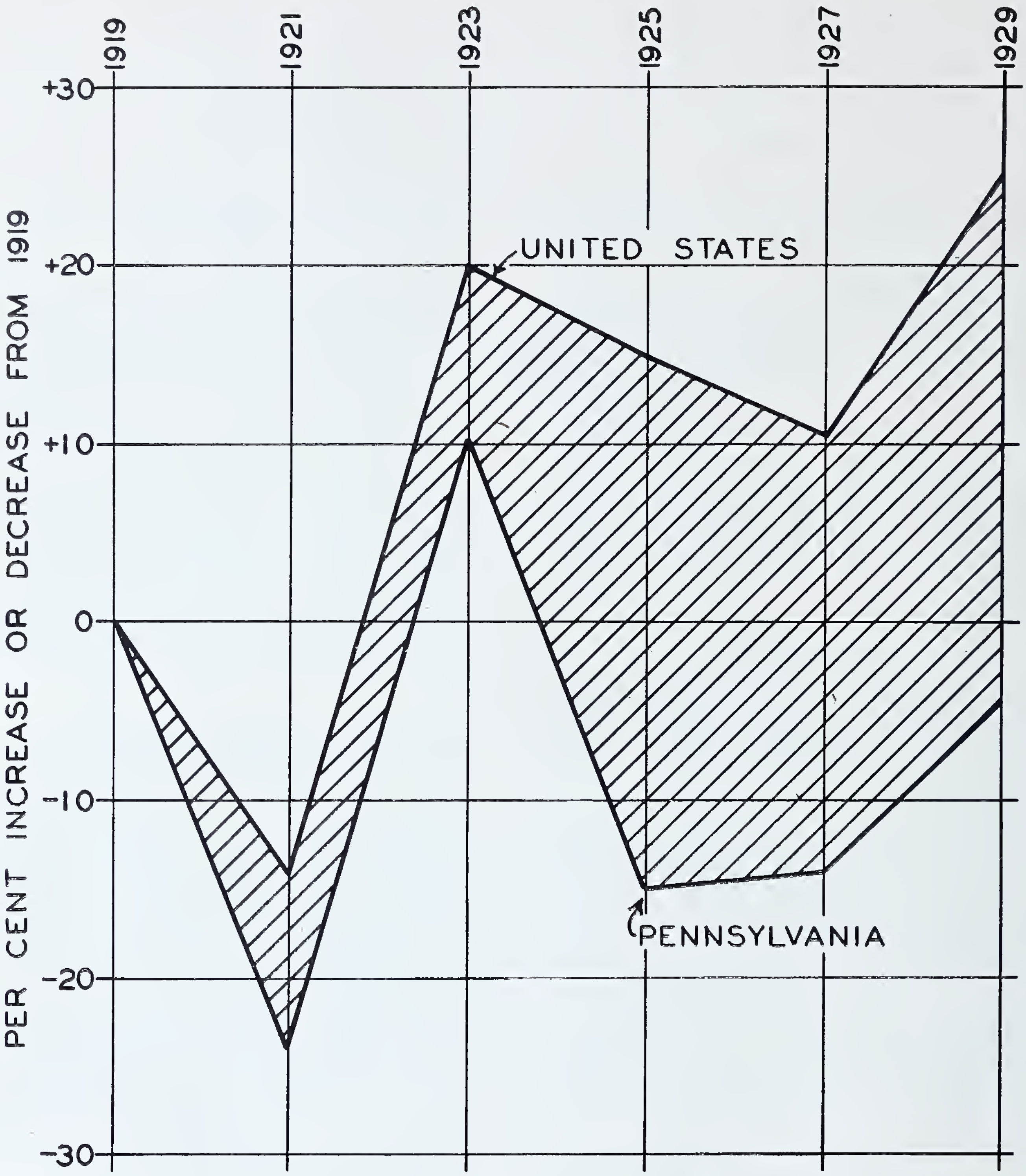

Fig. 107. Pennsylvania has not been keeping pace with the United States in value created by mineral industries.

taining solutions to some of their technical problems.

The metallurgical industry has long been engaged in research, most of the steel companies maintaining such laboratories of their own. Companies that have such laboratories have found them to be profitable investments.

The research of the industries, however, is still largely overshadowed by the programs of public and semi-public organizations such as the United States Bureau of Mines, the Mellon Institute of Industrial Research, and the various colleges and universities. Very often the private research laboratory of a company is kept so busy solving problems of immediate practical importance that it must neglect fundamental problems of greater long-range significance.

Long-range fundamental research is of vital importance to the nation; this type is most likely to be neglected in the private laboratories. The industrial research laboratories are constantly drawing upon the stock of fundamental knowledge and many practical achievements have resulted from research in pure science.

An extensive program of mineral industries research should be undertaken in Pennsylvania.

Such a program should be planned in advance over a long period and should be based on accurate information as to the physical resources of the State and its economic needs. The first step in such a program, making an inventory of our mineral resources, is now being carried on by the State Topographic and Geologic Survey. It should be carried much further and the information put in such form that the buyer of mineral products can ascertain almost at a glance whether he can obtain what he needs in the State, and, if so, where and in what quantities, under what conditions of transportation, and at what price. In addition, regional economic geographic studies are needed in order that industrial planning for the future may proceed along sound economic lines.

Based upon the economic geographic studies and the inventory of natural resources, a comprehensive long-time program of research should be developed for each of the mineral industries. In addition to a balanced proportion of fundamental research such a program should include studies in efficient recovery, processing, development of new and better products, better utilization of the resources, and marketing. New uses for the products of these industries must be devised in order that consumer demand may more nearly keep pace with production capacity. Trends in consumer preference must be studied and steps taken to meet any changes.

Discovery also offers future possibilities for Pennsylvania's mineral industries. A new science of geophysical or subsurface prospecting relying on delicate scientific instruments has grown up to supplement the older methods of the prospector and his burro. The Commonwealth should take advantage of this progress and check up on its resources once more.

Competition in the mineral industries is keen and Pennsylvania is losing ground. There is imperative need, therefore, for such a comprehensive program of research carried on by trained mineral technicians. Such a program has already been started, although in a modest way, in the School of Mineral Industries Experiment Station of The Pennsylvania State College in cooperation with various branches of these industries in Pennsylvania. The needs of industry are many and this program should be expanded as rapidly as it effectively can be. In view of the importance to the State of the mineral industries, a subsidized program comparable to that which has long been applied to the agricultural industry is to be desired.

Such subsidized programs have been under way in many other states, such as Illinois and West Virginia, but the accomplishments of these programs cannot solve the problems of Pennsylvania, since problems in the mineral industries are specific and local to a very large extent. Pennsylvania must solve her own problems if she is to maintain supremacy.

Although research is more fundamental, no less important is instruction of high quality in this field, including the thorough training of mineral industries workers.

Cooperation versus Competition

From the various chapters of this book one rightly gets an impression of intense competition between certain of the mineral industries both within Pennsylvania and elsewhere. Competition is particularly keen among the fuels, but there is strong rivalry for markets, too, among the various building materials, and among other mineral products. A certain amount of competition is stimulating, but the common result of such competition as that between the fuels is profitless operation for all. Industry and consumer alike would benefit if there could be more cooperation and less excessive competition.

The Future

As pointed out in the first chapter, mineral resources are the basis for Pennsylvania's present prominent position in the industrial world. Enough of these resources are still left, if they are properly utilized, to insure the State's maintenance of a leading position for many years. How many years she will maintain this position, or how much actual prosperity Pennsylvania will derive from her natural gifts, are matters which lie in the hands of her people.

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